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Preliminary Assessment of Radiation Doses to the Public from ^{137}Cs Contamination Along Railroad Tracks in Oak Ridge

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Environmental Restoration Division
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Preliminary Assessment of Radiation Doses to the Public from ^{137}Cs Contamination Along Railroad Tracks in Oak Ridge

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EXECUTIVE SUMMARY

This report presents a preliminary assessment of radiation doses to members of the public, including railroad workers, resulting from exposure to ^{137}Cs contamination along the CSX Transportation Group railroad tracks in Oak Ridge. The contamination, which has been characterized in radiological surveys by groups at Oak Ridge Associated Universities (ORAU) and Oak Ridge National Laboratory (ORNL), occurs primarily in sections of the railroad bed east and west of Scarboro Road near the Oak Ridge Y-12 Plant and in a limited area in the warehouse district of east Oak Ridge about 6 km from the Y-12 Plant. The contamination is believed to have resulted from waste operations in Oak Ridge during the early 1960s.

About 25% of the sections of the railroad bed along Scarboro Road near the Y-12 Plant surveyed by the ORAU group were found to be contaminated with ^{137}Cs. In the contaminated areas, the exposure rates at 1 m above ground were in the range 10 to 150 μR/h, and concentrations in ballast materials as high as 16,000 pCi/g (590 Bq/g) at a depth of 0–15 cm and 6800 pCi/g (250 Bq/g) at a depth of 15–30 cm were found.

In the warehouse district in east Oak Ridge surveyed by the ORNL group, the contamination is considerably more localized than in the area surveyed by the ORAU group. However, the levels of ^{137}Cs in the two contaminated areas appear to be similar, because the ORNL group measured maximum exposure rates at 1 m above ground in the range 7 to 75 μR/h and maximum concentrations of 22,000 pCi/g (810 Bq/g) at a depth of 0–15 cm and 9700 pCi/g (360 Bq/g) at a depth of 15–45 cm. In this report, separate analyses of radiation doses and environmental concentrations are presented for the areas surveyed by the ORAU and ORNL groups in order to permit separate decisions regarding needs for remediation of the contamination in these areas.

In order to assess the significance of radiation doses that might be received by the public from exposure to the ^{137}Cs contamination and to provide a basis for decisions regarding the need for remediation of the contamination, a set of guidelines for limiting exposures of the public to the contamination is proposed in this report. The proposed guidelines are as follows.

1. For reasonable scenarios for exposure of the public, including railroad workers, and including all exposure pathways, the annual effective dose equivalent from exposure to the ^{137}Cs contamination should not exceed 25 mrem (0.25 mSv) and the annual effective dose equivalent from exposure to all sources, including the ^{137}Cs contamination but excluding natural background radiation and deliberate medical practices, should not exceed 100 mrem (1 mSv).

2. For contaminated areas greater than 25 m^2, residual concentrations of ^{137}Cs averaged over an area of 100 m^2 should be limited to an average of about 15 pCi/g (0.6 Bq/g) in the first 15 cm of ballast materials or soil below the surface and an average of about 45 pCi/g (1.7 Bq/g) in 15-cm-thick layers more than 15 cm below the surface. For contaminated areas (A) of 25 m^2 or less, the concentration limits given above would be increased by a factor of $(100/A)^{1/2}$. For any localized area of contamination, the residual concentrations should be limited, to the extent reasonably achievable, to about 500 pCi/g

(20 Bq/g) in the first 15 cm below the surface and about 1500 pCi/g (55 Bq/g) at depths greater than 15 cm.

3. The concentration of ^{137}Cs in any groundwater or surface waters that are potentially usable as a drinking water supply for individuals or populations should not exceed 100 pCi/L (4 Bq/L).

4. Exposures of the public and residual concentrations of ^{137}Cs should be reduced below the limits given above as low as reasonably achievable (ALARA), taking into account technical, economic, and societal factors.

These guidelines are based on well-established precedents in standards for low-level waste operations, radiation protection standards for the public, generic guidelines for residual radioactive materials in land that could be released for unrestricted use by the public, and standards for radioactivity in drinking water.

An evaluation of the survey data on the ^{137}Cs contamination in conjunction with data on current releases of radioactivity from all operations on the Oak Ridge Reservation indicates that three of the guidelines listed above are potentially the most important in providing a basis for decisions regarding the need for remediation of the contamination. These include: (1) the limit on annual effective dose equivalent of 25 mrem (0.25 mSv) from exposure to the ^{137}Cs contamination, (2) the guidelines for residual concentrations of ^{137}Cs in surface materials, and (3) the ALARA requirement for reduction of dose and residual contamination.

The dose analysis considered exposure scenarios for members of the public, including railroad workers, at the present time and in the future. A distinction between present and future exposures is needed because, although the contaminated areas are accessible by the public at the present time, permanent residence in contaminated areas is precluded at the present time by ownership of the land by the railroad.

For members of the public at the present time and for railroad workers, the only reasonable exposure scenarios involve occasional exposure during a year. Furthermore, in any reasonable scenario, external exposure to the ^{137}Cs is likely to be more important than internal exposure via inhalation or ingestion. The results of the preliminary dose assessment for exposures at the present time may be summarized as follows.

1. For members of the public other than railroad workers, average annual effective dose equivalents are not likely to exceed 2 mrem (0.02 mSv).

2. During routine work activities that do not disturb contaminated materials, average annual effective dose equivalents for railroad workers are not likely to exceed 4 mrem (0.04 mSv).

3. For railroad workers who repair or replace railroad ties and ballast materials in contaminated areas, the dose rates could be considerably higher than those experienced by other railroad workers or members of the public. However, since these activities

should occur only infrequently and only for short periods of time, the dose in any year is not likely to be significantly higher than the average annual dose to railroad workers during routine activities given above. Furthermore, the annual effective dose equivalent averaged over a lifetime should be very low.

At some time in the future it is reasonable to assume that the contaminated land will revert to public ownership and, thus, that permanent residence on the land by members of the public could occur. If we assume that permanent residence would not occur until at least 30 years in the future, then average annual effective dose equivalents to residents are not likely to exceed 25 mrem (0.25 mSv).

Based on the results of the preliminary dose analysis, we believe that annual effective dose equivalents to members of the public including railroad workers, both at present and in the future, are unlikely to exceed the limit of 25 mrem (0.25 mSv) in the proposed guidelines for limiting exposures of the public to the ^{137}Cs contamination. Only for highly improbable scenarios would annual doses exceed 25 mrem (0.25 mSv), but in these cases we believe that the doses from all sources of exposure are quite unlikely to exceed the limit of 100 mrem (1 mSv) in current radiation protection standards for the public.

The survey data indicate that concentrations of ^{137}Cs in some portions of the railroad beds exceed the proposed guidelines developed in this report, which could be used to determine if the contaminated land may be released for unrestricted use by the public. We estimate that about 200 m^3 of material is contaminated above the proposed guideline for contaminated areas greater than 25 m^2 and that as much as a few tens of cubic meters could contain concentrations above the proposed guideline for localized sources.

The principal conclusions obtained from the preliminary assessments of dose and environmental contamination may be stated as follows.

1. The ^{137}Cs contamination along the railroad beds in Oak Ridge clearly does not present a significant health risk to railroad workers or other members of the public.

2. Because average doses to railroad workers or other members of the public from exposure to the ^{137}Cs contamination are unlikely to exceed the proposed limit on annual effective dose equivalent of 25 mrem (0.25 mSv), requirements for remediation of the contamination probably could be based entirely on the proposed guidelines for residual concentrations of ^{137}Cs in surface materials and application of the ALARA principle.

3. If remediation of the contamination were based on the proposed guidelines for residual concentrations of ^{137}Cs in surface materials and application of the ALARA principle, then there is little doubt that doses to railroad workers and other members of the public after remediation would be considerably less than the proposed limit of 25 mrem (0.25 mSv) per year for this source of exposure, regardless of any uncertainties in the estimates of dose for the different exposure scenarios considered in the analysis.

1. BACKGROUND AND SCOPE OF REPORT

In June 1986 the Radiological Survey Activities Group at Oak Ridge National Laboratory (ORNL) conducted a preliminary radiological survey along a portion of the CSX Transportation Group railroad tracks in Oak Ridge located east of Scarboro Road and across from the Oak Ridge Y-12 Plant. The results of this survey, as summarized in Appendix A to this report, indicated that portions of the railroad bed at this location contain elevated levels of ^{137}Cs.

In response to the preliminary and rather cursory survey by the ORNL group, a more comprehensive survey of the railroad beds along the east and west sides of Scarboro Road near the Y-12 Plant was performed in November 1986 by the Radiological Site Assessment Program at Oak Ridge Associated Universities (ORAU). The results of this survey, as given in Appendix B to this report, indicated that substantial portions of the railroad bed on both sides of Scarboro Road contain elevated levels of ^{137}Cs.

The initial surveys by the ORNL and ORAU groups covered only those sections of the railroad tracks in Oak Ridge near the Y-12 Plant. ORNL's Pollutant Assessment Group in Grand Junction, Colorado, thus undertook additional survey activities in March and June 1990. The survey began at the northernmost point included in the previous surveys (i.e., near the intersection of Scarboro Road and Bear Creek Road) and proceeded a distance of 11.2 km to the CSX main line at the east end of Oak Ridge. The results of this survey, as given in Appendix C to this report, indicated that additional portions of the railroad bed, primarily in the warehouse district in east Oak Ridge, contain elevated levels of ^{137}Cs.

The source of the ^{137}Cs contamination along the railroad tracks is somewhat uncertain. However, the contamination most likely occurred during the early 1960s when Oak Ridge served as the eastern regional burial ground for low-level radioactive waste generated by civilian and defense activities and such waste was routinely shipped to Oak Ridge by train. The particular source of the contamination has been tentatively identified as leaking concrete casks containing mostly ^{137}Cs-bearing animal carcasses (West 1989).

The contaminated railroad beds along the east and west sides of Scarboro Road lie outside fenced areas maintained by the Oak Ridge Utility District and the Y-12 Plant, respectively (see Fig. 1 in Appendix B), and no physical barriers are maintained along the railroad tracks that proceed from the vicinity of the Y-12 Plant to the east end of Oak Ridge. Thus, all contaminated areas are easily accessible by the public at the present time, and an important question is whether the levels of ^{137}Cs contamination could result in significant radiation doses to members of the public, including railroad workers.

The report on the initial ORNL survey in Appendix A does not include an assessment of potential doses to the public. In another summary of this survey (Foley 1986), the ORNL group concluded that the contamination does not pose an immediate health threat to the public. However, since the contaminated area is accessible by the public, the levels of contamination were judged sufficiently high to be of concern.

The report on the ORAU survey in Appendix B noted that gamma exposure rates above background in some contaminated areas are sufficiently high that annual dose equivalents to members of the public resulting from continuous exposure could exceed the limit of 100 mrem (1 mSv) in radiation protection standards for the public that had been proposed by the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE). This dose limit is discussed further in Sect. 3.1 of this report. However, the ORAU group concluded that actual doses received by members of the public at the present time are unlikely to exceed the limit of 100 mrem (1 mSv) in a year because current uses of the contaminated areas ensure that continuous exposures will not occur. The ORAU group also noted that concentrations of ^{137}Cs in a substantial volume of ballast materials and soil in the railroad bed exceed an NRC guideline of 17 pCi/g (0.6 Bq/g) for determining contaminated sites that could be released for unrestricted use by the public. Guidelines for residual radioactive material are discussed further in Sect. 3.3 of this report.

The report on the recent ORNL survey in Appendix C does not include an assessment of potential doses to the public. However, as in the ORAU survey in Appendix B, the ORNL report notes that the concentrations of ^{137}Cs in some areas exceed the NRC guideline for release of land for unrestricted use by the public referred to above.

The primary purpose of this report is to present a preliminary assessment of radiation doses to the public, including railroad workers, resulting from the ^{137}Cs contamination along the CSX Transportation Group railroad tracks in Oak Ridge. The assessment considers doses that might be received in the future as well as at the present time.

The remainder of this report is organized as follows. Section 2 discusses some of the results from the three surveys of the railroad beds performed to date. Section 3 discusses proposed guidelines, which are mostly in the form of limits on radiation dose to the public or concentrations of ^{137}Cs in the environment, that could be used to provide a basis for decisions regarding the need for remediation of the contamination. Section 4 then presents the results of the preliminary dose assessment. The dose estimates are based primarily on the survey data in Appendixes B and C and subjective judgments regarding reasonable uses of the contaminated areas by members of the public, including railroad workers. This section also discusses the concentrations of ^{137}Cs in the railroad bed in relation to the proposed guidelines for release of contaminated land for unrestricted use by the public. Finally, Sect. 5 presents a summary of the report, the principal conclusions obtained from the preliminary dose analysis and the assessment of levels of ^{137}Cs contamination, and recommendations on possible refinements in the assessments of dose and environmental contamination.

2. DISCUSSION OF RADIOLOGICAL SURVEYS

This section discusses some of the data from the radiological surveys described in Appendixes A, B, and C to this report. Some of these data are discussed in more detail in Sects. 4.1 and 4.2.

2.1 INITIAL ORNL SURVEY

The report on the initial ORNL survey of the railroad beds east of Scarboro Road and across from the Y-12 Plant, as given in Appendix A to this report, contains only a brief description of the data. The ORNL group measured gamma exposure rates at the surface of the railroad bed and concentrations of ^{137}Cs in ballast materials in the bed.

An important finding in this survey was that most of the ^{137}Cs contamination occurs in localized areas, rather than relatively uniformly along the railroad tracks. Furthermore, in all contaminated areas, the elevated levels of ^{137}Cs were confined within a few meters of the tracks. These characteristics of the contamination were confirmed in the more comprehensive ORAU and ORNL surveys performed later.

The maximum gamma exposure rate at the surface was about 1 mR/h. At this location, a sample of ballast material between the surface and a depth of 2 in. (5 cm) contained 2100 pCi/g (78 Bq/g) of ^{137}Cs. At another location along an abandoned railroad spur, the gamma exposure rate at the surface was about 0.6 mR/h, and a sample contained 880 pCi/g (30 Bq/g) of ^{137}Cs. The highest gamma exposure rates are about 2 orders of magnitude greater than outdoor exposure rates due to natural background radiation in the Oak Ridge area, and the highest concentration of ^{137}Cs in the ballast material is 3 to 4 orders of magnitude greater than background levels of this isotope in surface soils (see Sect. 2.2).

Since the area investigated in the initial ORNL survey was characterized in more detail in the ORAU survey described in Sect. 2.2 below, the results of the initial ORNL survey are not used in the assessments presented in Sects. 4.1 and 4.2 of this report.

2.2 ORAU SURVEY

The report on the ORAU survey of the railroad beds east and west of Scarboro Road near the Y-12 Plant, as given in Appendix B to this report, contains detailed data on gamma exposure rates at the surface and at 1 m above ground, concentrations of ^{137}Cs in samples of ballast materials and underlying soil at locations of elevated gamma exposure at the surface, and concentrations of activity in water and sediments in a stream crossed by the railroad tracks. Background gamma exposure rates and background levels of ^{137}Cs in surface soil also are given.

For purposes of dose assessment and planning for remediation, a potentially useful piece of information is the fraction of the railroad bed that contains elevated levels of ^{137}Cs. From

Figs. 2 and 5 of Appendix B, we estimate that about 25% of the railroad bed in the area surveyed by the ORAU group near the Y-12 Plant is contaminated.

The ORAU report states that background gamma exposure rates in the Oak Ridge area are in the range 6 to 12 μR/h. From the survey data in Tables 3 and 4 of Appendix B, the exposure rates at the surface in contaminated areas on the east and west sides of Scarboro Road are in the range 15 to 490 μR/h, and the corresponding exposure rates at 1 m above ground are in the range 10 to 150 μR/h. At a few locations, exposure rates were measured after removal of some ballast materials, and the exposure rates at the surface in these cases are in the range 13 to 560 μR/h.

The ^{137}Cs concentrations in ballast and soil in the contaminated areas east and west of Scarboro Road are given in Tables 7 and 8 of Appendix B. At each location, measurements were made at different depth intervals below the surface. In almost all cases, the highest concentration of ^{137}Cs was found within the first 15 cm of the surface, and, in the few exceptions, the highest concentration was found at a depth of 15–30 cm. At all locations most of the contamination was confined to the first 60 cm below the surface. Thus, only a small fraction of the contamination apparently has migrated downward from the ballast materials into the underlying soil. The contamination also was confined within a few meters of the railroad tracks. At the location of maximum concentrations, the value is about 16,000 pCi/g (590 Bq/g) at a depth of 0–15 cm and 6800 pCi/g (250 Bq/g) at a depth of 15–30 cm. The ORAU report states that background levels of ^{137}Cs in soil in the Oak Ridge area are in the range 0.1 to 2 pCi/g (0.004 to 0.07 Bq/g).

Activity concentrations in water and sediment samples obtained from a small drainage stream crossed by the railroad tracks are given in Table 9 of Appendix B. The concentrations of gross alpha and gross beta activity in water and ^{137}Cs in sediments are typical of background levels in the Oak Ridge area. These data provide further evidence of the lack of movement of the contamination from the railroad bed.

2.3 RECENT ORNL SURVEY

The report on the recent ORNL survey of the railroad bed between the Y-12 Plant and the east end of Oak Ridge, as given in Appendix C to this report, contains data on gamma exposure rates at the surface and at 1 m above ground and concentrations of ^{137}Cs in soil at selected locations of elevated gamma exposure at the surface. Concentrations of gross alpha and beta activity, ^{90}Sr, and total uranium also were measured in soil at a few locations of elevated gamma exposure.

Only a small fraction of the 11.2-km length of railroad tracks surveyed was found to be contaminated, and the contamination was found to be more localized than in the area surveyed by the ORAU group. As shown in Figs. 1 and 4A of Appendix C, nine of the ten localized regions of ^{137}Cs contamination were found in the warehouse district in east Oak Ridge and occur only over a distance of about 0.2 km, and the remaining contaminated region near the Y-12 Plant has an area less than 1 m^2. Thus, we estimate that only about 2% of the railroad bed in the area surveyed by the ORNL group is contaminated. The contamination in these areas also is confined within a few meters of the railroad tracks.

From Table 1 of Appendix C, the gamma exposure rates at the surface in the contaminated areas near the Y-12 Plant and in east Oak Ridge are in the range 10 to 850 μR/h, and the maximum exposure rates at 1 m above ground are in the range 7 to 75 μR/h. The maximum exposure rate at the surface of 850 μR/h is about a factor of 2 greater than the maximum value along Scarboro Road observed in the ORAU survey described in Sect. 2.2, but the maximum exposure rate at 1 m above ground of 75 μR/h is about a factor of 2 less than the maximum value observed in the ORAU survey.

Concentrations of ^{137}Cs were measured in four contaminated areas in the warehouse district in east Oak Ridge, and the results are given in Table 2 of Appendix C. At the location of maximum concentration, the value is about 22,000 pCi/g (810 Bq/g) at a depth of 0–15 cm, and the concentrations at depths of 15–45 cm are in the range 4100 to 9700 pCi/g (150 to 360 Bq/g). These maximum concentrations are similar to the highest values measured in the railroad beds along Scarboro Road by the ORAU group, as described in Sect. 2.2. Concentrations below a depth of 45 cm were not measured at any location. Since few depth profiles of ^{137}Cs were measured by the ORNL group, it is not possible to compare the ORNL and ORAU surveys in regard to retention of the contamination in the upper layers of ballast material and soil.

In the other analyses of samples summarized in Table 3 of Appendix C, the concentrations of gross beta activity are essentially the same as the concentrations of ^{137}Cs. The concentrations of gross alpha activity and total uranium are low and probably represent background levels in the Oak Ridge area. The concentrations of ^{90}Sr also are low, typically less than 2 pCi/g (0.07 Bq/g). The absence of elevated levels of ^{90}Sr probably indicates that the contamination did not arise from nuclear fuel-cycle wastes, which is consistent with the presumed origin of the contamination discussed in Sect. 1.

Three additional anomalies were found in the ORNL survey: (1) gamma exposure rates as much as an order of magnitude higher than background levels in the vicinity of the Quadrex Plant, which originated from stored radioactive waste at this site; (2) a single small rock along the railroad tracks giving an exposure rate of 15 μR/h, but around which no additional contamination was found; and (3) an 85-m section of ballast giving slightly elevated exposure rates at the surface in the range 9 to 13 μR/h, which resulted from naturally occurring radioactivity in the material. Since these anomalies did not result from the ^{137}Cs contamination of concern to this report, they are not considered further in the dose analysis presented in Sect. 4.1.

3. PROPOSED GUIDELINES FOR LIMITING PUBLIC EXPOSURES TO ^{137}Cs CONTAMINATION

This section presents proposed guidelines for limiting radiation exposures of the public that could be applied to the ^{137}Cs contamination along the railroad tracks in Oak Ridge. These guidelines would apply to railroad workers as well as other members of the general public. The potential importance of the different guidelines in determining the need for remediation of the contamination is discussed.

The proposed guidelines are based on certain standards and guidelines for limiting radiation exposures of the public that have been developed by NRC, DOE, and the Environmental Protection Agency (EPA). These standards and guidelines, which are reviewed in Sects. 3.1–3.4, include (1) radiation protection standards, (2) standards for radioactivity in drinking water, (3) generic guidelines for residual radioactive material in soil, and (4) standards for management of low-level radioactive wastes. Section 3.5 then discusses the reportable quantities of radionuclides in the environment developed by the EPA. Finally, Sect. 3.6 presents the proposed guidelines that could be applied to the ^{137}Cs contamination.

3.1 RADIATION PROTECTION STANDARDS

Radiation protection standards for the public apply to all sources of exposure, exclusive of natural background radiation and deliberate medical practices. These standards define exposure limits that correspond to a limit on acceptable radiation risk to members of the public. Regardless of the responsible agency at the time the ^{137}Cs contamination occurred and the agency responsible for any remediation in the future, the ^{137}Cs contamination presumably is a source of exposure that falls under the jurisdiction of radiation protection standards for the public.

Radiation protection standards for the public have been developed by NRC for its licensees and by DOE for its operations. The NRC's current standards in Title 10, Code of Federal Regulations, Part 20 (10 CFR Part 20) (NRC 1990a) specify a limit on annual dose equivalent from uniform whole-body irradiation of 500 mrem (5 mSv). However, proposed revisions of these standards (NRC 1986), which should soon be issued in final form, specify a limit on annual effective dose equivalent of 100 mrem (1 mSv), and the same dose limit has been adopted by DOE in the new Order 5400.5 on radiation protection of the public and the environment (DOE 1990). For exposure to ^{137}Cs, dose equivalent to whole body and effective dose equivalent are essentially the same.

Thus, a limit on annual effective dose equivalent of 100 mrem (1 mSv) from all sources of exposure, including the ^{137}Cs contamination but excluding natural background and medical practices, should be regarded as the current radiation protection standard for the public. This standard conforms to recommendations of the International Commission on Radiological Protection (ICRP 1977, ICRP 1985) and the National Council on Radiation Protection and Measurements (NCRP 1987).

Annual effective dose equivalents to the public from all radioactive discharges from the Oak Ridge Reservation currently are less than 10 mrem (0.1 mSv); e.g., see Rogers et al.

(1988). Thus, in principle, annual effective dose equivalents of nearly 100 mrem (1 mSv) from exposure of the public to the ^{137}Cs contamination would be permitted by current radiation protection standards. However, the impending NRC and current DOE radiation protection standards (NRC 1986, DOE 1990) also specify that all exposures of the public shall be reduced as low as reasonably achievable (ALARA). Therefore, in practice, consideration of technical, economic, and societal factors most likely would indicate that actions should be taken to reduce annual dose equivalents from the ^{137}Cs contamination well below 100 mrem (1 mSv) if doses approaching this limit could reasonably be experienced by members of the public.

3.2 DRINKING WATER STANDARDS

The EPA has developed interim standards for radioactivity in drinking water in 40 CFR Part 141 (EPA 1989a). These standards apply only to community water systems (i.e., public or private water systems with at least 15 service connections or serving at least 25 persons) and only at the tap rather than at the source. The standards specify dose limits from man-made, beta/gamma-emitting radionuclides, and the limit for ^{137}Cs is an annual dose equivalent to whole body of 4 mrem (0.04 mSv). For drinking water supplies operated by or for DOE, Order 5400.5 (DOE 1990) specifies a limit on annual effective dose equivalent of 4 mrem (0.04 mSv) from all radionuclides except those that are naturally occurring. If we assume ingestion of 2 L of drinking water per day and the committed effective dose equivalent per unit activity of ^{137}Cs ingested recommended by the ICRP (1979), then the limit on annual dose equivalent of 4 mrem (0.04 mSv) corresponds to a concentration limit for ^{137}Cs in drinking water of about 100 pCi/L (4 Bq/L).

According to the ORAU and ORNL surveys in Appendixes B and C, respectively, the ^{137}Cs contamination is largely confined to an area within a few meters of the railroad tracks and to ballast materials and surface soil. Furthermore, no groundwaters near the contaminated areas currently provide drinking water for any public or private water system or DOE facility, and any contamination that might reach the Clinch River would be greatly diluted in concentration before intake at a public, private, or DOE water system. Thus, protection of existing drinking water supplies from the ^{137}Cs contamination in accordance with current standards apparently would not be an important factor in determining the need for remediation of the contamination at the present time and probably will not be of concern in the future.

According to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, the EPA's drinking water standards also may be applied to cleanup of contaminated groundwater at sites containing hazardous materials, including radionuclides. That is, the drinking water standards may be used to limit concentrations of radionuclides in groundwater at Superfund sites, without regard to whether the activity could be removed by water treatment systems or whether the source is supplying drinking water for individuals or populations at the present time. The drinking water standards also could be applied in the same way to surface waters near contaminated areas.

A surface stream that crosses the railroad tracks near the Y-12 Plant was sampled during the ORAU survey (see Appendix B), but no sampling of groundwaters was performed.

Significant groundwater contamination appears unlikely, however, because the ORAU survey showed that most of the ^{137}Cs is confined to the ballast materials in the railroad bed but very little contamination is found in native soil beneath the ballast or away from the railroad bed. No sampling of groundwater or surface waters was performed in the ORNL survey described in Appendix C.

We showed above that current drinking water standards for ^{137}Cs correspond to a concentration limit in water of about 100 pCi/L (4 Bq/L), and this limit could be applied to the stream crossing the contaminated area near the Y-12 Plant. According to the ORAU survey (see Table 9 of Appendix B), the gross beta activity in the stream is only about 5 pCi/L (0.2 Bq/L). Therefore, there is no indication of significant migration of ^{137}Cs from the railroad bed to the surface stream, and it appears unlikely that application of drinking water standards to contamination of this stream could be important in determining the need for remediation. It also appears unlikely that the ^{137}Cs in the warehouse district in east Oak Ridge could result in significant contamination of nearby groundwater or surface waters, because the ^{137}Cs in this area also appears to be confined near the ground surface and close to the railroad bed.

If neither the surface stream near the Y-12 Plant nor groundwaters near contaminated areas could provide drinking water for individuals, then drinking water standards probably would not be applied to these sources. Rather, derived concentration guides (DCGs) in water, such as those specified in DOE Order 5400.5 (DOE 1990), would apply. Since DCGs are based on a limit on annual effective dose equivalent of 100 mrem (1 mSv) from drinking water, which is a factor of 25 higher than the dose limit in current drinking water standards, the DCG for ^{137}Cs is 3 nCi/L (110 Bq/L). There is no indication that such a high concentration will occur in the surface stream or any groundwaters.

3.3 GENERIC GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

DOE Order 5400.5 (DOE 1990) contains requirements for limiting residual radioactive material in soil, including rubble and debris that may be present in soil, that will be used to determine if contaminated property at sites over which DOE has authority, or which were contaminated by operations of DOE or its predecessor agencies, may be released for unrestricted use by the public. If DOE is assumed to have jurisdiction over the ^{137}Cs contamination, then these requirements would be applied to remediation of the contamination.

The DOE order specifies a basic dose limit for exposure to residual radioactive material that is the same as the dose limit in radiation protection standards for the public discussed in Sect. 3.1, i.e., a limit on annual effective dose equivalent of 100 mrem (1 mSv). In addition, the ALARA principle shall be applied in reducing doses from exposure to residual radioactive material below the basic dose limit.

The DOE order also provides that generic guidelines for residual concentrations of radionuclides in soil may be used in lieu of a dose analysis to demonstrate compliance with the basic dose limit of 100 mrem (1 mSv) in a year, unless site-specific data indicate that the use of such guidelines could result in doses above the limit. The order includes generic guidelines for widespread contamination, i.e., radionuclide concentrations above background averaged over an area of 100 m^2, and for localized contamination, i.e., radionuclide concentrations above background in areas of 25 m^2 or less. For example, for widespread contamination, the generic guideline for ^{226}Ra in soil is a concentration limit of 5 pCi/g (0.2 Bq/g) averaged over the first 15 cm of soil below the surface and a limit of 15 pCi/g (0.6 Bq/g) averaged over 15-cm-thick layers more than 15 cm below the surface.

For radionuclides other than radium and thorium, the DOE order specifies that generic guidelines for residual concentrations in soil for widespread contamination shall be derived from the basic dose limit of 100 mrem (1 mSv) in a year using procedures given in a DOE manual (Gilbert et al. 1989). We have not derived the guideline for widespread ^{137}Cs contamination using the DOE procedures. However, since external exposure is the most important pathway for both ^{226}Ra and ^{137}Cs in surface soil, we can estimate the concentrations of ^{137}Cs that would give the same external dose as the generic guideline for ^{226}Ra given above. Using the known photon energies and intensities emitted by these radionuclides and their daughter products (Kocher 1981) and calculated absorbed dose rates in air above ground from uniformly distributed slab sources of monoenergetic photons in soil (Kocher and Sjoreen 1985), we find that the external dose rate from a given concentration of ^{137}Cs in soil is about one-third of the dose rate from the same concentration of ^{226}Ra. Thus, the estimated generic guideline for residual concentrations of ^{137}Cs averaged over the first 15 cm of soil below the surface is a limit of 15 pCi/g (0.6 Bq/g). This value is in reasonable agreement with an NRC guideline of 17 pCi/g (0.6 Bq/g) noted by the ORAU group in Appendix B and the guideline of 30 pCi/g (1 Bq/g) developed by DOE for the Niagara Falls Storage Site (Yu et al. 1988). Similarly, at depths greater than 15 cm below the surface, the estimated generic guideline for ^{137}Cs is a concentration limit of 45 pCi/g (1.7 Bq/g) averaged over 15-cm-thick layers. Again, the generic guidelines for ^{137}Cs in surface soil derived above apply to the concentrations averaged over an area of 100 m^2.

The generic guidelines for residual radioactive material in soil include two provisions for localized sources (DOE 1990). First, in contaminated areas of 25 m^2 or less, the generic guideline for any surface or subsurface area is given by the generic guideline for widespread contamination discussed above multiplied by a factor of $(100/A)^{1/2}$, where A is the area of the contamination in m^2. Second, every reasonable effort shall be made to remove any material in which radionuclide concentrations exceed 30 times the generic guideline for widespread contamination, regardless of the average concentration in soil. On the basis of the generic guideline for widespread ^{137}Cs contamination derived in the previous paragraph, application of the second provision would give limits on residual concentrations of ^{137}Cs in any localized area of about 500 pCi/g (20 Bq/g) in the first 15 cm below the surface and 1500 pCi/g (55 Bq/g) at depths more than 15 cm below the surface.

Data in Tables 7 and 8 of Appendix B and in Table 2 of Appendix C indicate that the generic guidelines for widespread and localized ^{137}Cs contamination derived in this section are exceeded at a number of locations along the railroad tracks in Oak Ridge. Thus, the generic guidelines evidently would be important in determining the need for remediation of the contamination. Comparisons of the data with these guidelines are discussed further in Sect. 4.2.

3.4 STANDARDS FOR LOW-LEVEL WASTE MANAGEMENT

Standards for management of low-level radioactive wastes have been established or proposed by NRC, DOE, and EPA. These standards apply only to present or future low-level waste operations. However, if the ^{137}Cs contamination resulted from past operations (West 1989), then these standards reasonably could be applied to the contamination.

NRC's 10 CFR Part 61 (NRC 1990b) specifies a limit on annual dose equivalent to whole body for members of the public of 25 mrem (0.25 mSv) from operations at a low-level waste disposal facility and that every reasonable effort shall be made to maintain exposures ALARA. DOE Order 5820.2A (DOE 1988) and EPA's proposed 40 CFR Part 193 (EPA 1987) both specify a limit on annual effective dose equivalent to members of the public of 25 mrem (0.25 mSv) from management of low-level waste. Therefore, a limit on annual effective dose equivalent of 25 mrem (0.25 mSv) would be a reasonable standard for limiting public exposures to the ^{137}Cs contamination. That is, it would be reasonable to apply the same standards to remediation of past low-level waste operations as are applied to such operations at present or in the future (Kocher 1989).

3.5 REPORTABLE QUANTITIES OF RADIONUCLIDES

CERCLA specifies that the National Response Center shall be notified if there is a release of any hazardous substance, including radionuclides, to the environment from vessels or facilities equal to or greater than its reportable quantity (RQ). This requirement also applies to any past releases that may be discovered; i.e., the requirement presumably applies to the ^{137}Cs contamination along the railroad tracks in Oak Ridge. However, it must be emphasized that RQs do not define environmental releases that require remediation, nor do they define acceptable levels of contamination following remediation. The required reporting of releases greater than RQs is intended only to assist EPA in prioritizing cleanup activities for protection of public health and the environment.

EPA has established RQs for radionuclides in 40 CFR Part 302 (EPA 1989b). The values are based on a limit on effective dose equivalent to members of the public of 500 mrem (5 mSv) and *very conservative* analyses of dose from inhalation, ingestion of contaminated groundwater, or external exposure. Because of the conservative nature of the dose analyses used in deriving RQs for specific radionuclides, the values are not directly related to actual doses that might be received by members of the public, particularly in the case of past releases. The RQ for ^{137}Cs established by EPA is 1 Ci (0.04 TBq).

In the region along Scarboro Road near the Y-12 Plant, the ORAU group concluded that about 180 m^3 of ballast material and soil contains concentrations of ^{137}Cs in excess of an NRC guideline of 17 pCi/g (0.6 Bq/g); see Appendix B. From the data in Tables 7 and 8 of Appendix B, the average concentration in all ballast and soil samples with concentrations of ^{137}Cs greater than the NRC guideline is about 800 pCi/g (30 Bq/g). If we assume an average density of ballast and soil of 3 g/cm^3, then the estimated total activity of ^{137}Cs in the 180 m^3 of contaminated ballast and soil is about 0.4 Ci (0.01 TBq).

In the region between the Y-12 Plant and the east end of Oak Ridge, the ORNL group concluded that about 47 m^3 of material contains concentrations of ^{137}Cs in excess of the NRC guideline of 17 pCi/g (0.6 Bq/g); see Appendix C. From the data in Table 2 of Appendix C, the average concentration in all samples with concentrations of ^{137}Cs greater than the NRC guideline is about 5100 pCi/g (190 Bq/g). For an assumed density of material of 3 g/cm^3, the estimated total activity of ^{137}Cs in the 47 m^3 of contaminated material is about 0.7 Ci (0.03 TBq).

From the calculations described above, and assuming that the volumes of contaminated material identified in the ORAU and ORNL surveys contain most of the ^{137}Cs, we estimate that the total activity of ^{137}Cs in the contaminated areas along the railroad tracks in Oak Ridge is about 1 Ci (0.04 TBq), which is the same as the RQ for this radionuclide (EPA 1989b). Although this estimate is highly uncertain, perhaps by as much as an order of magnitude, it thus is possible that the total release of ^{137}Cs to the environment could have exceeded the RQ.

3.6 PROPOSED GUIDELINES FOR ^{137}Cs CONTAMINATION

Based on the review in Sects. 3.1–3.4 of certain standards and guidelines for limiting radiation exposures of the public, we propose that the four guidelines described below could be applied in determining the need and requirements for remediation of the ^{137}Cs contamination along the railroad tracks in Oak Ridge.

1. For reasonable scenarios for exposure of the public, including railroad workers, and including all exposure pathways, the annual effective dose equivalent from exposure to the ^{137}Cs contamination should not exceed 25 mrem (0.25 mSv), and the annual effective dose equivalent from exposure to all sources, including the ^{137}Cs contamination but excluding natural background radiation and deliberate medical practices, should not exceed 100 mrem (1 mSv).

2. For contaminated areas greater than 25 m^2, residual concentrations of ^{137}Cs averaged over an area of 100 m^2 should be limited to an average of about 15 pCi/g (0.6 Bq/g) in the first 15 cm of ballast materials or soil below the surface and an average of about 45 pCi/g (1.7 Bq/g) in 15-cm-thick layers more than 15 cm below the surface. For contaminated areas (A) of 25 m^2 or less, the concentration limits given above would be increased by a factor of $(100/A)^{1/2}$. For any localized area of contamination, the residual concentrations should be limited, to the extent reasonably achievable, to about 500 pCi/g (20 Bq/g) in the first 15 cm below the surface and about 1500 pCi/g (55 Bq/g) at depths greater than 15 cm.

3. The concentration of ^{137}Cs in any groundwater or surface waters that are potentially usable as a drinking water supply for individuals or populations should not exceed 100 pCi/L (4 Bq/L).

4. Exposures of the public and residual concentrations of ^{137}Cs should be ALARA; i.e., doses and residual concentrations should be reduced below the limits given above to the extent reasonably achievable, taking into account technical, economic, and societal factors.

The dose limits of 25 mrem (0.25 mSv) and 100 mrem (1 mSv) in the first proposed guideline are based on current standards for low-level waste operations, which is the presumed source of the ^{137}Cs contamination (West 1989), and current radiation protection standards for the public, respectively. The second proposed guideline is based on DOE's generic guidelines for residual radioactive materials in land that could be released for unrestricted use by the public. The third proposed guideline is based on current standards for radioactivity in drinking water. The fourth proposed guideline is an essential component of ICRP's recommended system of dose limitation (ICRP 1977) and is required by current radiation protection standards for the public.

Of the proposed guidelines listed above, we believe that the following three are potentially the most important in providing a basis for decisions regarding the need for remediation of the ^{137}Cs contamination: (1) the dose limit of 25 mrem (0.25 mSv) in a year from exposure to the ^{137}Cs contamination, (2) the limits on residual concentrations of ^{137}Cs in surface soil, and (3) the ALARA requirement for reduction of dose and residual concentrations. On the other hand, given current releases of radioactivity from all operations on the Oak Ridge Reservation, we believe that the dose limit in the first guideline of 100 mrem (1 mSv) in a year from all sources of exposure is not likely to be approached if the lower dose limit from exposure to the ^{137}Cs contamination is met. Compliance with the dose limit of 100 mrem (1 mSv) in a year also is implicit in the generic guidelines on residual concentrations of ^{137}Cs in surface soil. On the basis of the survey data, which indicate that the ^{137}Cs contamination is largely confined near the ground surface and in the immediate vicinity of the railroad tracks, we also believe that the guideline for protection of existing drinking water supplies and potential sources of drinking water is not likely to be important in determining the need for remediation of the contamination. However, this conclusion may require verification by additional environmental sampling, particularly of groundwater in contaminated areas.

EPA's RQs of radionuclides (EPA 1989b) discussed in Sect. 3.5 presumably apply to the ^{137}Cs contamination. We estimated that the total release of ^{137}Cs to the environment may have exceeded the RQ of 1 Ci (0.04 TBq). However, this conclusion is highly uncertain and would require a more careful evaluation. Furthermore, even if the total release exceeded the RQ, the only requirement is that the National Response Center be notified of the release. That is, RQs do not define needs for remediation or acceptable levels of contamination following remediation.

4. ASSESSMENTS OF DOSE AND ENVIRONMENTAL CONTAMINATION

This section presents the preliminary assessment of radiation doses to the public, including railroad workers, resulting from the ^{137}Cs contamination along the railroad tracks in Oak Ridge. The dose assessment is based primarily on measured gamma exposure rates from the ORAU and ORNL surveys in Appendixes B and C, respectively, and subjective judgments regarding reasonable exposure scenarios in contaminated areas. It must be emphasized that rigorous data to support a dose analysis, particularly exposure times in contaminated areas, generally are lacking.

Measured concentrations of ^{137}Cs in ballast and soil in the railroad beds also are discussed. Given DOE's generic guidelines on residual radioactive material in soil discussed in Sect. 3.3, these data are important in determining the need for remediation of the contamination.

In presenting the dose assessment, results based on the ORAU survey in Appendix B often are given separately from results based on the ORNL survey in Appendix C, primarily because (1) the contamination in the region surveyed by the ORAU group appears to be somewhat more widespread than in the region surveyed by the ORNL group and (2) most of the contamination found by the ORNL group occurs a considerable distance (about 5.5 km) from the region surveyed by the ORAU group. A separation of the two surveys in the dose assessment would permit separate decisions regarding needs for remediation of the contamination in the two regions.

4.1 DOSE ESTIMATES

4.1.1 Exposure Scenarios

The radiological surveys by the ORAU and ORNL groups indicate that the ^{137}Cs contamination is found primarily in the ballast materials and top layer of underlying soil in the railroad bed, but very little activity is found in deeper layers of soil beneath the ballast or more than a few meters away from the railroad tracks. On the other hand, the contamination usually is distributed throughout a few tens of centimeters of ballast and soil, rather than confined just to the surface.

Given the observed distributions of ^{137}Cs in contaminated areas and that all contaminated areas are accessible by the public, we believe that the most important exposure scenario at the present time for members of the public other than railroad workers involves external exposure during such occasional activities as walking along the railroad tracks. External exposure also should be of primary importance for railroad workers. Exposures of railroad workers are evaluated separately in this analysis because activities of these individuals in contaminated areas may be significantly different from activities of other members of the public.

Inhalation of ^{137}Cs suspended in air probably is not important for members of the public other than railroad workers, because only the small fraction of the total activity very near the ground surface is subject to suspension. Even in the unlikely event that the average atmospheric mass loading of respirable contaminated material above the railroad bed were as high as 10^{-7} kg/m^3, which is an average dust loading in air (Anspaugh et al. 1975), the dose from inhalation of ^{137}Cs would be insignificant compared with the dose from external exposure. For example, for the *maximum* concentration of ^{137}Cs in surface materials of about 22,000 pCi/g (810 Bq/g), as given in Table 2 of Appendix C, and assuming a breathing rate of 1200 L/h for light activity (ICRP 1975) and the committed effective dose equivalent per unit activity of ^{137}Cs inhaled recommended by the ICRP (1979), the effective dose-equivalent rate from inhalation would be less than 0.1 μrem/h (0.001 μSv/h), which is much less than the dose rates from external exposure discussed later in this section. The inhalation dose to individuals residing near the railroad tracks would be considerably less than the inhalation dose at locations along the railroad bed, due primarily to dilution during transport of the airborne contaminant to receptor locations.

Ingestion of ^{137}Cs by residents near the railroad tracks also is quite unlikely to be important. Residents could ingest garden vegetables contaminated by foliar deposition or by root uptake of activity deposited in soil but, as argued above, the concentrations of ^{137}Cs at the location of a nearby resident's garden should be very low. In addition, ingestion of vegetables grown directly in the contaminated areas is not a credible scenario at the present time, because the railroad owns the land and the railroad bed is not suitable for gardening.

For an individual walking along the railroad bed, activity could be transferred from ballast materials and soil to the feet, hands, and other parts of the body, and activity on the hands could be directly ingested. However, significant external and internal contamination of members of the public other than railroad workers according to such a scenario probably is unlikely, again because most of the ^{137}Cs is located below the surface of the railroad bed.

For railroad workers, inhalation exposures, external contamination of the body, and ingestion exposures could be more important than for other members of the public. These exposure pathways are discussed in Sect. 4.1.6 in presenting the dose assessment for railroad workers.

4.1.2 Calculation of Dose Equivalent

The gamma exposure rate at 1 m above ground, rather than at the surface, is the relevant quantity for estimating dose equivalent to an individual standing on the ground. However, an exposure in air of 1 R does not correspond to an effective dose equivalent (or dose equivalent to whole body) for an exposed individual of 1 rem. Based on the conversion from exposure to absorbed dose in air of 1 rad = 0.877 R (Cember 1983) and the conversion from absorbed dose in air to effective dose equivalent to an individual standing on the ground of 1 rem = 0.8 rad (Jacob et al. 1988), we obtain the following factor for converting exposure to effective dose equivalent:

$$\text{effective dose equivalent (rem)} = 0.7 \times \text{air exposure (R)} .$$

4.1.3 Gamma Exposure Rates

The report on the ORAU survey in Appendix B states that background gamma exposure rates from all sources in the Oak Ridge area are in the range 6 to 12 μR/h. In estimating doses from the ^{137}Cs contamination, the contribution from natural background should be subtracted from the measured exposure rates. For purposes of this assessment, a background exposure rate at 1 m above ground of 7 μR/h is assumed. This value is consistent with measurements by the ORNL group [(see Appendix A of *Survey Report for the Characterization of Radiological Contamination of the CSX Transportation Group Railroad Tracks, Oak Ridge, Tennessee* (Appendix C to this report)] over considerable sections of the railroad bed that are not significantly contaminated with ^{137}Cs.

From Tables 3 and 4 of Appendix B, the gamma exposure rates at 1 m above ground in the areas of elevated exposure along Scarboro Road near the Y-12 Plant surveyed by the ORAU group are in the range 10 to 150 μR/h. These measurements may be summarized as follows:

- The arithmetic mean of all exposure rates in contaminated areas along both sides of Scarboro Road is 19 μR/h; i.e., the average exposure rate above background attributable to the ^{137}Cs contamination in these areas is about 12 μR/h.

- At 5% of the measurement locations, all on the west side of Scarboro Road, the exposure rate above background exceeds 30 μR/h, and the highest value is about 140 μR/h above background.

From Table 1 of Appendix C, the *maximum* gamma exposure rates at 1 m above ground in the areas of elevated exposure surveyed by the ORNL group, most of which are in the warehouse district in east Oak Ridge, are in the range 7 to 75 μR/h. The maximum exposure rates are used in this analysis, rather than an average of the minimum and maximum values at each location, because detailed data on exposure rates within each area were not reported. These measurements may be summarized as follows:

- The arithmetic mean of the maximum exposure rates in the ten contaminated areas identified in the survey is 32 μR/h; i.e., the average exposure rate above background attributable to the ^{137}Cs contamination in these areas is less than 25 μR/h.

- In four of the ten contaminated areas, the maximum exposure rate above background is about 38 μR/h or higher, and the highest value is about 70 μR/h above background.

4.1.4 Annual Dose Equivalents from Continuous Exposure

On the basis of the gamma exposure rates at 1 m above ground summarized above and the factor for converting exposure to effective dose equivalent of 0.7 rem/R derived previously, we obtain estimates of annual effective dose equivalents at the present time *from continuous exposure during the year in the contaminated areas* given below.

In the contaminated areas along Scarboro Road near the Y-12 Plant surveyed by the ORAU group:

- the average annual effective dose equivalent above background would be about 70 mrem (0.7 mSv);

- at 5% of the measurement locations, all on the west side of Scarboro Road, the annual effective dose equivalent above background would exceed 180 mrem (1.8 mSv); and

- at the location of highest exposure rate, the annual effective dose equivalent above background would be about 900 mrem (9 mSv).

In the contaminated areas, mostly in the warehouse district in east Oak Ridge, surveyed by the ORNL group:

- the average annual effective dose equivalent above background would be less than 150 mrem (1.5 mSv);

- in four of the ten contaminated areas, the maximum annual effective dose equivalent above background would exceed 200 mrem (2 mSv); and

- at the location of highest exposure rate, the annual effective dose equivalent above background would be about 400 mrem (4 mSv).

Thus, even with the unrealistic assumption of continuous exposure during the year, the average annual effective dose equivalent above background in the region along Scarboro Road would be less than the limit of 100 mrem (1 mSv) in current radiation protection standards for the public, and the average dose above background in the region in east Oak Ridge would not exceed this dose limit by more than 50%. In accordance with ICRP recommendations (ICRP 1977), the average dose, rather than the maximum value, is the appropriate measure of potential radiological impact when individuals can access all contaminated areas with equal likelihood, as is the case with the contaminated railroad beds in Oak Ridge. Furthermore, only at a relatively few locations in the contaminated areas, particularly along Scarboro Road, would the dose from continuous exposure exceed the limit in radiation protection standards.

4.1.5 Annual Dose Equivalents for Realistic Exposure Times

The dose estimates given above are based on the assumption of continuous exposure during the year. Such an assumption is completely unrealistic because permanent residence in contaminated areas is precluded by current ownership and uses of the land. A more realistic dose assessment requires reasonable assumptions for the amount of time that members of the public might spend in contaminated areas.

Estimates of reasonable exposure times are largely a matter of subjective judgment, because data generally are lacking on residence times in contaminated areas. Since the railroad owns the land and the contaminated areas are limited in extent and not located close to residential areas at the present time, members of the public other than railroad workers clearly would be exposed only occasionally. In this analysis, two different approaches are taken in estimating doses based on more realistic exposure times. The use of different assumptions in estimating dose permits some evaluation of the sensitivity of the results to the assumptions made.

In the first approach, we assume a maximum exposure time *in the contaminated areas* of 2 h/week, or 1% of the time (about 100 h) during the year. We believe it is unlikely that members of the public, including nearby residents, would spend even this amount of time in contaminated areas, particularly in the highly localized areas of contamination in east Oak Ridge. We then obtain estimates of annual effective dose equivalents at the present time given below.

In the contaminated areas along Scarboro Road near the Y-12 Plant surveyed by the ORAU group:

- the average annual effective dose equivalent above background would be about 0.7 mrem (0.007 mSv);

- at 5% of the measurement locations, all on the west side of Scarboro Road, the annual effective dose equivalent above background would exceed 1.8 mrem (0.018 mSv); and

- at the location of highest exposure rate, the annual effective dose equivalent above background would be about 9 mrem (0.09 mSv).

In the contaminated areas, mostly in the warehouse district in east Oak Ridge, surveyed by the ORNL group:

- the average annual effective dose equivalent above background would be less than 1.5 mrem (0.015 mSv);

- in four of the ten contaminated areas, the maximum annual effective dose equivalent above background would exceed 2 mrem (0.02 mSv); and

- at the location of highest exposure rate, the annual effective dose equivalent above background would be about 4 mrem (0.04 mSv).

Thus, under present conditions and given the stated assumptions, the ^{137}Cs contamination in either area would result in average annual effective dose equivalents to members of the public other than railroad workers of less than 2 mrem (0.02 mSv). This dose is far less than the limit of 25 mrem (0.25 mSv) in a year for this source of exposure proposed in Sect. 3.6. Again, the average dose is the appropriate quantity for comparison with dose limits when access to all contaminated areas is equally likely. Even at the location of highest exposure rate, where exposures for 1% of the time during the year are highly improbable, the annual effective dose equivalent would be less than 10 mrem (0.1 mSv). This dose is also less than the proposed limit of 25 mrem (0.25 mSv) in a year for this source of exposure.

In the second approach to more realistic estimates of dose, we assume that an individual spends 1 h/d, or about 4% of the time during the year, *at random locations* (i.e., in uncontaminated as well as contaminated areas) along any of the railroad beds surveyed by the ORAU and ORNL groups. This assumption could apply, for example, to an individual who walks regularly along the tracks. Since the location of exposed individuals is assumed to be random, the fraction of the railroad bed that is contaminated must be taken into account in estimating dose. Furthermore, in this approach, the average dose while in contaminated areas is the only relevant quantity for the dose assessment.

In the areas along Scarboro Road near the Y-12 Plant surveyed by the ORAU group, we estimated in Sect. 2.2 that about 25% of the railroad bed is contaminated. Therefore, based on the assumption of random exposure in these areas for 4% of the time during the year:

- the average annual effective dose equivalent above background would be about 0.7 mrem (0.007 mSv).

In the areas surveyed by the ORNL group, mostly in the warehouse district in east Oak Ridge, we estimated in Sect. 2.3 that only about 2% of the railroad bed is contaminated. Therefore, based on the assumption of random exposure in these areas for 4% of the time during the year:

- the average annual effective dose equivalent above background would be less than 0.12 mrem (0.0012 mSv).

Thus, under present conditions and given the stated assumptions, the ^{137}Cs contamination in either area would result in average annual effective dose equivalents to members of the public other than railroad workers of less than 1 mrem (0.01 mSv). As in the first approach to the dose analysis presented previously, this dose is far less than the limit of 25 mrem (0.25 mSv) per year for this source of exposure proposed in Sect. 3.6. We also believe that the assumed exposure time of 1 h/d throughout the year probably overestimates reasonable residence times along the railroad beds at the present time.

For the two approaches used in estimating dose, the average doses from the contamination along Scarboro Road are the same, because the difference in the assumed exposure time is exactly compensated by the assumed fraction of the area that is contaminated. However, for the two approaches, the average doses from the contamination along the railroad bed in east Oak Ridge differ by about an order of magnitude. These results show that the dose estimates are sensitive to the areal extent of the contamination in a particular region in addition to the assumptions regarding exposure times. Again, however, we believe it is unlikely that doses as high as the average values estimated using either approach would be experienced at the present time.

4.1.6 Exposures of Railroad Workers

Exposures of railroad workers would be subject to the same dose limits as exposures of other members of the public. However, exposures of railroad workers warrant special consideration because their activities and exposure times in contaminated areas could differ significantly from those for other individuals.

Data on exposure times for railroad workers are lacking. However, we believe it is unlikely that such individuals would be located in contaminated areas more than a small fraction of the time. Even for an exposure time *in contaminated areas* of 10% of the working hours during the year (i.e., about 200 h), which we believe is unreasonably high, the results of the previous dose analysis for other members of the public show that the *average* annual effective dose equivalent above background would be less than 2 mrem (0.02 mSv) in the areas surveyed by the ORAU group and less than 4 mrem (0.04 mSv) in the areas surveyed by the ORNL group. These estimates do not take into account the reductions in dose that would occur while working inside railroad cars. Therefore, at the present time, we believe that annual external doses to railroad workers during routine activities that do not disturb railroad ties or ballast materials in the railroad bed would be far less than the limit of 25 mrem (0.25 mSv) for this source of exposure proposed in Sect. 3.6.

Railroad workers who handle railroad ties or ballast materials could receive higher doses than other workers. First, data in Tables 3 and 4 of Appendix B indicate that removal of ballast may substantially increase gamma exposure rates at the surface of the railroad bed, and increases in the exposure rate at 1 m above ground also could occur. Second, external doses could result from transfer of activity to the hands or clothing during the handling of contaminated materials. Third, activity transferred to the hands could be ingested, e.g., while eating. Finally, the atmospheric mass loading of activity undoubtedly would increase during the handling of contaminated materials, resulting in increased inhalation doses.

Data to support a rigorous dose analysis for the four exposure pathways described above generally are not available. The following analyses for these pathways are presented primarily for illustrative purposes. However, we believe that the results probably overestimate actual doses that railroad workers would receive while handling contaminated materials in the railroad bed.

For the first pathway, we assume that the increase in external dose rate at 1 m above ground during the handling of contaminated materials would be similar to the observed increase in gamma exposure rate at the surface after removal of ballast materials, as indicated in Tables 3 and 4 of Appendix B. In the data from the ORAU survey, the exposure rate at the surface increased after sample removal by about 35% on the average, and the largest increase was a factor of 3.6.

Using these results in conjunction with the gamma exposure rates in the ORAU and ORNL surveys summarized previously, we estimate that (1) in the contaminated areas along Scarboro Road, the average exposure rate above background would be about 16 μR/h and the maximum exposure rate at any location could be as high as 500 μR/h and (2) in the contaminated areas in east Oak Ridge, the average exposure rate above background would be less than 34 μR/h and the maximum exposure rate at any location could be as high as 250 μR/h. Then, the corresponding effective dose-equivalent rates would be (1) an average of about 0.01 mrem/h (0.1 μSv/h) and a maximum of about 0.35 mrem/h (3.5 μSv/h) in the contaminated areas along Scarboro Road and (2) an average of less than 0.024 mrem/h (0.24 μSv/h) and a maximum of about 0.18 mrem/h (1.8 μSv/h) in the contaminated areas in east Oak Ridge.

We caution, however, that the maximum dose rates given above may be considerably overestimated, because the data in Tables 2 and 3 of Appendix B also indicate that the greatest increases in exposure rate at the surface after sample removal do not occur at locations with the highest exposure rates at 1 m above ground. Therefore, we believe that the more meaningful results, although they are uncertain, are the estimated average dose rates after sample removal given above.

For the second pathway, it is difficult to estimate external dose to railroad workers from contamination of clothing and the body surface because it is difficult to estimate the concentrations of activity that would be deposited on an exposed worker. However, since the work activities would take place in open areas, it is virtually certain that the external dose from contamination of clothing and the body surface would be significantly less than the external dose from activity remaining on the ground because only a small fraction of the activity in the ballast materials and soil could be transferred to a worker's body. The use of gloves and normal cleaning of the hands and clothing also would serve to reduce the importance of this exposure pathway.

For the third pathway, we estimate dose rates from ingestion of activity that has been transferred to the hands using the following assumptions: (1) a rate of ingestion of contaminated material of 0.01 g/h, i.e., a daily ingestion of 0.1 g (EG&G Idaho 1986); (2) an average concentration of ^{137}Cs in ingested material in the contaminated areas along Scarboro Road of about 1300 pCi/g (50 Bq/g), as obtained from the data for the first 15 cm below the ground surface in Tables 7 and 8 of Appendix B, and an average concentration in ingested material in the contaminated areas in east Oak Ridge of about 6000 pCi/g (200 Bq/g), as obtained from the less extensive data for the first 15 cm below ground in Table 2 of Appendix C; and (3) the committed effective dose equivalent per unit activity of ^{137}Cs ingested recommended by the ICRP (1979). We then obtain estimated effective dose-equivalent rates from ingestion of about 0.0007 mrem/h (0.007 μSv/h) in the contaminated areas along Scarboro Road and 0.003 mrem/h (0.03 μSv/h) in the contaminated areas in east Oak Ridge. These estimates are considerably less than the dose rates from external exposure that are incurred during the handling of contaminated materials given above.

For the fourth pathway, we estimate dose rates from inhalation using the following assumptions: (1) an atmospheric mass loading of respirable contaminated materials of 10^{-5} kg/m^3, which is 2 orders of magnitude greater than an average dust loading in air (Anspaugh et al. 1975) and probably overestimates airborne concentrations of inhaled materials that would occur during work activities; (2) average concentrations of ^{137}Cs in the top layer of ballast of about 1300 pCi/g (50 Bq/g) along Scarboro Road and about 6000 pCi/g (200 Bq/g) in east Oak Ridge, obtained as described above in the analysis of the ingestion pathway; (3) a breathing rate of 2200 L/h for a mixture of light activity and heavy work (ICRP 1975); and (4) the committed effective dose equivalent per unit activity of ^{137}Cs inhaled recommended by the ICRP (1979). We then obtain estimated effective dose-equivalent rates from inhalation of about 0.001 mrem/h (0.01 μSv/h) in the contaminated areas along Scarboro Road and 0.004 mrem/h (0.04 μSv/h) in the contaminated areas in east Oak Ridge. These estimates also are considerably less than the dose rates from external exposure that are incurred during the handling of contaminated materials given above.

From the analyses presented above, we conclude that the average effective dose-equivalent rate to railroad workers during the handling of contaminated materials would be about 0.01 mrem/h (1 μSv/h) in the contaminated areas along Scarboro Road and about 0.03 mrem/h (3 μSv/h) in the contaminated areas in east Oak Ridge. Most of the dose would result from external exposure to activity on the ground. Although these dose rates are about 40% higher than the dose rates when contaminated materials in the railroad bed are not disturbed by workers, the exposure times while handling contaminated materials probably would be no more than a few tens of hours. Furthermore, such activities probably would take place in contaminated areas no more than once or twice during a working lifetime (West 1989). Therefore, (1) annual doses averaged over a lifetime from infrequent handling of contaminated materials by railroad workers should be very low, (2) the dose in any year may be less than the annual dose from routine activities that do not disturb contaminated materials, and (3) the dose in any year probably would be much less than the limit of 25 mrem (0.25 mSv) for this source of exposure proposed in Sect. 3.6.

4.1.7 Doses in the Future

At some time in the future, the contaminated railroad beds may revert to public ownership, and members of the public could permanently reside on the contaminated land at that time. However, even for individuals who grow foodstuffs in contaminated soil, the dose from external exposure to ^{137}Cs is expected to be about 2 orders of magnitude higher than the dose from ingestion and inhalation (Kocher and O'Donnell 1987). Therefore, from the dose analysis for continuous exposure during the year presented previously, we estimate that the average annual effective dose equivalent above background in contaminated areas would not exceed 70 mrem (0.7 mSv) for a resident in the area along Scarboro Road and would be less than 150 mrem (1.5 mSv) for a resident in the warehouse district in east Oak Ridge, regardless of when residence first occurs. Again, the average dose, rather than the maximum value at any location, is the appropriate measure of radiological impact when permanent residence could occur at random locations in contaminated areas.

The dose estimates given above do not take into account two important factors that would reduce the dose. First, the estimated dose would be reduced by about a factor of 3 if a more reasonable exposure time in contaminated areas of 50% and a shielding factor during indoor residence of 0.7 were assumed (Kocher and O'Donnell 1987). Therefore, even if permanent residence in contaminated areas could occur at the present time, the average annual effective dose equivalent to residents would be about 25 mrem (0.25 mSv) in the area along Scarboro Road and less than 50 mrem (0.5 mSv) in the area in east Oak Ridge. While these doses could exceed the limit of 25 mrem (0.25 mSv) per year for this source of exposure proposed in Sect. 3.6, the doses from all sources of exposure probably would not exceed the limit of 100 mrem (1 mSv) per year in current radiation protection standards for the public.

Second, since permanent residence cannot occur at the present time, due to ownership of the land by the railroad, the dose would be reduced over time because of radioactive decay of ^{137}Cs. If permanent residence would not occur for at least 30 years, which may be a reasonable assumption, then the dose would be reduced by at least a factor of 2. In 30 years, the estimated average annual effective dose equivalents to residents in contaminated areas would be about 10 mrem (0.1 mSv) in the area along Scarboro Road and less than 25 mrem (0.25 mSv) in the area in east Oak Ridge. Thus, in east Oak Ridge, the dose at that time could approach the limit of 25 mrem (0.25 mSv) per year for this source of exposure proposed in Sect. 3.6. However, the dose would be reduced below this limit if permanent residence in contaminated areas were delayed beyond 30 years.

4.2 CONCENTRATIONS OF ^{137}Cs IN BALLAST MATERIALS AND SOIL

As discussed in Sect. 3.3, DOE Order 5400.5 (DOE 1990) includes generic guidelines for residual radioactive material in soil that could be used to determine if the contaminated railroad beds may be released for unrestricted use by the public. On the basis of the generic guidelines for ^{226}Ra, we derived the following tentative guidelines for ^{137}Cs:

- for contaminated areas greater than 25 m^2, concentration limits averaged over an area of 100 m^2 of 15 pCi/g (0.6 Bq/g) averaged over the first 15 cm below the surface and 45 pCi/g (1.7 Bq/g) averaged over 15-cm-thick layers more than 15 cm below the surface;

- for contaminated areas (A) of 25 m^2 or less, an increase in the concentration limits given above by a factor of $(100/A)^{1/2}$; and

- for any localized area of contamination, and to the extent reasonably achievable, concentration limits of 500 pCi/g (20 Bq/g) in the first 15 cm and 1500 pCi/g (55 Bq/g) at depths below 15 cm.

In the area along Scarboro Road surveyed by the ORAU group, the concentrations of ^{137}Cs in samples of ballast materials and soil at locations of elevated gamma exposure rate at the surface are given in Tables 7 and 8 of Appendix B. The report on the ORAU survey states that the volume of material to a depth of 30 cm that contains concentrations of ^{137}Cs exceeding an NRC guideline of 17 pCi/g (0.6 Bq/g) is about 180 m^3. Although the NRC guideline and the tentative guideline for contaminated areas greater than 25 m^2 given above are not directly comparable, it may be reasonable to assume that the volumes of material to a depth of 30 cm that would exceed the two guidelines are approximately the same. At some locations, the concentrations below 30 cm also exceed the tentative guideline for areas greater than 25 m^2, but it is not possible to estimate the affected volume of contaminated material in this case.

In about 40% of the samples measured by the ORAU group, the ^{137}Cs concentration in the first 15 cm exceeds the tentative guideline for localized sources of 500 pCi/g (20 Bq/g) given above, but less than 10% of the samples from depths below 15 cm contain concentrations exceeding the tentative guideline of 1500 pCi/g (55 Bq/g). The high concentrations in the first 15 cm appear to occur in about ten separate locations, and the high concentrations below 15 cm occur in three locations. The ORAU report does not give estimated volumes of material associated with concentrations above these limits. However, on the basis of the data given in the report, it is possible that as much as a few tens of cubic meters of material could contain concentrations of ^{137}Cs exceeding 500 pCi/g (20 Bq/g) in the first 15 cm or 1500 pCi/g (55 Bq/g) at depths below 15 cm.

In the data from the ORAU survey, it is noteworthy that the gamma exposure rate at 1 m above ground, which is proportional to dose equivalent for individuals standing on the ground, does not correlate well with the ^{137}Cs concentration in the first 15 cm of material unless the exposure rate is relatively high. From the data in Tables 3, 4, 7, and 8 of Appendix B, exposure rates at 1 m above ground tend to increase with increasing concentration of ^{137}Cs in the first 15 cm only for concentrations greater than about 1000 pCi/g (40 Bq/g), which exceeds the tentative guideline of 500 pCi/g (20 Bq/g) for localized sources; and even at such high concentrations, the exposure rate at 1 m above ground does not always increase significantly compared with values at locations with lower concentrations. The correlation between exposure rate and concentration of ^{137}Cs in the first 15 cm is somewhat improved if the exposure rate at the surface is used; i.e., the exposure rate at the surface tends to increase with increasing concentration in the first 15 cm for concentrations greater than about 300 pCi/g (10 Bq/g).

The observations described above probably result from the variability in shielding provided by ballast materials at the different sampling locations, combined with the fact that most of the ^{137}Cs is not confined to the ground surface. More important, these observations indicate that areas of elevated contamination below the surface may not have been located from measurements of gamma exposure rate at or above the surface.

In comparison with the ORAU survey described above, only a relatively few samples from the warehouse district in east Oak Ridge were analyzed for ^{137}Cs contamination in the ORNL survey presented in Appendix C. In the report on the ORNL survey, the estimated volume of material to a depth of 45 cm that contains ^{137}Cs concentrations exceeding the NRC guideline of 17 pCi/g (0.6 Bq/g) is 47 m^3. As with the ORAU survey, we can only assume that this volume is approximately the same as the volume of material with concentrations exceeding the tentative guideline for contaminated areas greater than 25 m^2 developed in this report.

As indicated in Table 2 of Appendix C, the ORNL group measured concentrations of ^{137}Cs in only nine samples and at only three of the ten contaminated locations identified in the survey. At two of these locations, identified as E and G, the concentrations exceed the tentative guideline for localized sources developed in this report. From the contaminated areas at these two locations given in Table 1 of Appendix C, the area over which the ^{137}Cs concentrations exceed the tentative guideline for localized contamination could be as high as 75 m^2. Therefore, at these two locations, the much lower guidelines for extended areas of contamination probably would apply. As with the ORAU survey, it is not possible to estimate the volume of material in which the concentrations exceed the tentative guideline for localized sources.

4.3 SUMMARY OF DOSE ASSESSMENT

This section has presented a preliminary assessment of potential radiation doses to the public resulting from exposure to the ^{137}Cs contamination along the CSX Transportation Group railroad tracks in Oak Ridge. Separate analyses were performed for railroad workers and other members of the public because the two groups could engage in different activities in the contaminated areas and dose rates and annual doses for railroad workers could be higher. The analysis also distinguished between the contamination along Scarboro Road near the Y-12 Plant and the contamination beyond the Y-12 Plant, principally in the warehouse district in east Oak Ridge, in order to permit separate decisions regarding remediation of the contamination in the two areas.

It must be emphasized that there is considerable uncertainty in defining exposure scenarios and exposure times for members of the general public and for railroad workers. However, in any reasonable scenario, external exposure to the ^{137}Cs should be much more important than inhalation or ingestion. In accordance with ICRP recommendations (ICRP 1977), the analysis emphasized estimates of doses that would not likely be exceeded for *average* individuals in affected population groups. The results of the dose assessment may be summarized as follows.

- For members of the public other than railroad workers, we believe that exposure times during the year in contaminated areas of the railroad bed probably would not exceed 1%

(about 100 h). Then, for an assumed exposure time of 1%, average annual effective dose equivalents at the present time probably would be less than 2 mrem (0.02 mSv). Even if an individual spent 1% of the time at locations with the highest exposure rates, which we believe is highly unlikely, annual effective dose equivalents at the present time would be less than 10 mrem (0.1 mSv).

- During routine work activities that do not disturb contaminated materials, exposure times for railroad workers in contaminated areas could be higher than for other members of the public. However, we believe it is unlikely that exposure times during the year for railroad workers would exceed 2% (about 200 h). Then, for an assumed exposure time of 2%, average annual effective dose equivalents at the present time would be less than 4 mrem (0.04 mSv). During routine activities, it is not credible that a railroad worker could spend as much as 2% of the time during the year at locations with the highest exposure rates.

- Railroad workers who repair or replace railroad ties and ballast materials in comtaminated areas could experience higher dose rates than other railroad workers or members of the public. However, these activities should occur only infrequently and only for short periods of time. Therefore, although estimates of external, inhalation, and ingestion doses during work activities that disturb contaminated materials are highly uncertain, we believe that (1) annual effective dose equivalents averaged over a lifetime should be very low and (2) the dose in any year is not likely to be significantly higher than the average annual dose to railroad workers during routine activities given above.

- If we assume that the contaminated land will not revert to public ownership within the next 30 years, then average annual effective dose equivalents to permanent residents on the contaminated land in the future probably would be less than 25 mrem (0.25 mSv). Even if permanent residence could occur in the near future, which is highly unlikely, average annual effective dose equivalents in contaminated areas probably would be less than 50 mrem (0.5 mSv).

Thus, we believe that annual effective dose equivalents to members of the public including railroad workers, both at present and in the future, are unlikely to exceed the limit of 25 mrem (0.25 mSv) for this source of exposure proposed in Sect. 3.6. Only for highly improbable scenarios would annual doses exceed 25 mrem (0.25 mSv), but in these cases we believe that the doses from all sources of exposure still are quite unlikely to exceed the limit of 100 mrem (1 mSv) in current radiation protection standards for the public.

The dose assessment also considered measured concentrations of ^{137}Cs in ballast materials and soil along the railroad beds in relation to tentative guidelines that could be used to determine if the contaminated land may be released for unrestricted use by the public. The guidelines include concentration limits that would apply to widespread areas of contamination (i.e., areas greater than 25 m^2) and higher concentration limits that would apply to more localized contamination.

There is considerable uncertainty in estimating volumes of material in which the concentrations of ^{137}Cs exceed any proposed guidelines. However, on the basis of the available survey data, it is possible that more than 200 m^3 of material is contaminated above the tentative guideline for widespread areas of 15 pCi/g (0.6 Bq/g) averaged over the first

15 cm below the surface and 45 pCi/g (1.7 Bq/g) averaged over 15-cm-thick layers more than 15 cm below the surface. In addition, the concentrations at a number of locations exceed the tentative guideline for localized sources of 500 pCi/g (20 Bq/g) in the first 15 cm and 1500 pCi/g (55 Bq/g) at depths below 15 cm, and the volume of material containing concentrations above this guideline could be as much as a few tens of cubic meters.

5. SUMMARY AND CONCLUSIONS

This report has discussed potential radiological impacts on the public, including railroad workers, resulting from exposure to the ^{137}Cs contamination along the CSX Transportation Group railroad tracks in Oak Ridge. These impacts are of concern because the contaminated areas are accessible by the public at the present time.

5.1 PROPOSED GUIDELINES FOR ^{137}Cs CONTAMINATION

In Sect. 3 of this report, proposed guidelines for limiting radiation exposures of the public to the ^{137}Cs contamination were developed. The proposed guidelines provide a framework for judging the significance of the contamination in regard to potential radiological impacts on the public, and they could provide a basis for decisions regarding the need for remediation of the contamination for the purpose of protecting public health and the environment.

The proposed guidelines for the ^{137}Cs contamination are based on certain standards and guidelines for limiting radiation exposures of the public developed by NRC, DOE, and EPA: (1) radiation protection standards, which apply to all sources of exposure exclusive of natural background radiation and deliberate medical practices; (2) standards for radioactivity in drinking water; (3) generic guidelines for residual radioactive material in soil, which could be used to determine if contaminated property may be released for unrestricted use by the public; and (4) standards for management of low-level radioactive wastes. The proposed guidelines include the following:

1. for reasonable exposure scenarios for the public, including railroad workers, a limit on annual effective dose equivalent from exposure to the ^{137}Cs contamination of 25 mrem (0.25 mSv) and a limit on annual effective dose equivalent from exposure to all sources, including the ^{137}Cs contamination but excluding natural background radiation and deliberate medical practices, of 100 mrem (1 mSv);

2. for contaminated areas greater than 25 m^2, limits on concentrations of ^{137}Cs averaged over an area of 100 m^2 of 15 pCi/g (0.6 Bq/g) averaged over the first 15 cm below the ground surface and 45 pCi/g (1.7 Bq/g) averaged over 15-cm-thick layers more than 15 cm below the surface; for contaminated areas (A) of 25 m^2 or less, an increase in the concentration limits given above by a factor of $(100/A)^{1/2}$; and, for any localized area of contamination, and to the extent reasonably achievable, limits on concentrations of 500 pCi/g (20 Bq/g) in the first 15 cm below the surface and 1500 pCi/g (55 Bq/g) at depths greater than 15 cm;

3. a limit on the concentration of ^{137}Cs in any groundwater or surface waters that are potentially usable as a drinking water supply of 100 pCi/L (4 Bq/L); and

4. reduction of doses to the public and residual concentrations of ^{137}Cs ALARA, taking into account technical, economic, and societal factors.

On the basis of the survey data in Appendixes B and C, we believe that the dose limit of 25 mrem (0.25 mSv) per year from exposure to the ^{137}Cs contamination, the guidelines on residual concentrations of ^{137}Cs in surface soil, and the ALARA requirement for reduction of dose and residual concentrations are potentially the most important in providing a basis for decisions regarding the need for remediation of the contamination. On the other hand, the available data indicate that the dose limit of 100 mrem (1 mSv) per year from exposure to all sources and the limit on concentration of ^{137}Cs in potential drinking water supplies are likely to be less important in determining the need for remediation.

RQs of radionuclides established by EPA were discussed in Sect. 3.5. The RQ for ^{137}Cs is 1 Ci (0.04 TBq). On the basis of an uncertain analysis of the available survey data, we concluded that the total release of ^{137}Cs may have exceeded the RQ. However, the only requirement in this case would be to notify the National Response Center of the release. In particular, RQs do not define levels of environmental contamination that require remediation, nor do they define acceptable levels of contamination following remediation.

5.2 ASSESSMENTS OF DOSE AND ENVIRONMENTAL CONTAMINATION

Section 4.1 presented a preliminary analysis of radiation doses that might be received by members of the public from exposure to the ^{137}Cs contamination. The analysis distinguished between railroad workers and other members of the public, because the exposure scenarios and exposure times could differ significantly for the two population groups. Separate analyses also were presented for the contamination along Scarboro Road near the Y-12 Plant and the contamination beyond the Y-12 Plant, primarily in the warehouse district in east Oak Ridge, to permit separate decisions concerning remediation in these two locations.

In performing the preliminary dose analysis, there was considerable uncertainty in defining appropriate exposure scenarios and exposure times in contaminated areas, and these uncertainties cannot easily be quantified or resolved. However, the most important consideration is that the assumed exposure scenarios should be reasonably likely to occur. Furthermore, the dose analysis should focus primarily on *average* doses in the affected population groups, rather than maximum but highly unlikely doses. For example, even though the contaminated areas are accessible by the public at the present time, it is not reasonable to assume continuous exposure of any individuals, because continuous exposure is precluded by such factors as private ownership of the contaminated areas, separation of residential areas from the railroad tracks, and the types of activities performed by railroad workers. Thus, reasonable scenarios at the present time involve occasional exposure during the year or infrequent exposure over a lifetime. It is also not reasonable to assume that individuals will be exposed only in those highly localized areas where the dose would be the highest, because individuals most likely would be exposed at random locations in the contaminated areas.

The results of the dose analysis for exposure scenarios that we believe are reasonably likely to occur may be summarized as follows:

- At the present time, average annual effective dose equivalents to members of the public, including railroad workers during routine work activities or during repair or replacement of railroad ties and ballast materials in contaminated areas, are not likely to exceed a few mrem (a few hundredths of a mSv).

- Average annual effective dose equivalents to individuals who might permanently reside on the contaminated land in the future are not likely to exceed 25 mrem (0.25 mSv), provided the land does not revert to public ownership within the next 30 years.

Thus, we believe it is unlikely that members of the public, including railroad workers, could receive annual effective dose equivalents greater than the proposed limit of 25 mrem (0.25 mSv) for exposure to the ^{137}Cs contamination, either at present or in the future.

In Sect. 4.2, we considered the data on concentrations of ^{137}Cs in ballast materials and soil in relation to the proposed guidelines for contaminated land that could be released for unrestricted use by the public. We concluded that:

- a substantial volume of material, perhaps at least 200 m^3, may be contaminated above the proposed guideline for areas greater than 25 m^2, which applies to concentrations averaged over an area of 100 m^2, of 15 pCi/g (0.6 Bq/g) averaged over the first 15 cm below the surface and 45 pCi/g (1.7 Bq/g) averaged over 15-cm-thick layers more than 15 cm below the surface; and

- the concentrations at a substantial number of locations exceed the proposed guideline for localized areas of 500 pCi/g (20 Bq/g) in the first 15 cm below the surface and 1500 pCi/g (55 Bq/g) at depths greater than 15 cm, and a few tens of cubic meters of material may contain concentrations in excess of this guideline.

Thus, although the proposed guidelines on residual concentrations of ^{137}Cs are tentative and the estimated volumes of material containing concentrations in excess of the guidelines are uncertain, the analysis indicates that some cleanup of the contaminated areas probably is called for, unless institutional controls are maintained that would preclude unrestricted use of the land by the public. In regard to the guideline for localized areas of contamination, DOE requires only that every reasonable effort shall be made to remove any radioactive material that exceeds the guideline. Judgments regarding what constitutes a reasonable effort involve considerations of technical, economic, and societal factors. However, the results of the preliminary dose analysis indicate that potential doses to members of the public, including railroad workers, probably would not be the most important factor in judging the extent of cleanup that is reasonable. Rather, cost-benefit considerations in reducing concentrations below the guidelines and public perceptions of the significance of the contamination probably would be more important.

5.3 PRINCIPAL CONCLUSIONS

The principal conclusions obtained from the preliminary assessments of dose and environmental contamination may be stated as follows:

- The ^{137}Cs contamination clearly does not present a significant health risk to railroad workers or other members of the public. This conclusion is based on the likelihood that annual doses to either population group at any time would not approach the limit in current radiation protection standards for the public of 100 mrem (1 mSv), which is widely assumed to ensure an acceptable risk from radiation exposure.

- Because average doses to railroad workers or other members of the public are unlikely to exceed the proposed limit on annual effective dose equivalent of 25 mrem (0.25 mSv) from exposure to the ^{137}Cs contamination, assuming reasonable exposure scenarios, requirements for remediation of the contamination probably could be based entirely on the proposed guidelines for residual concentrations of ^{137}Cs in soil and application of the ALARA principle.

- If remediation of the contamination were based on the proposed guidelines for residual concentrations of ^{137}Cs in soil and on the application of the ALARA principle, then there is little doubt that doses to railroad workers and other members of the public after remediation would be considerably less than the proposed limit of 25 mrem (0.25 mSv) per year for this source of exposure, regardless of any uncertainties in the estimates of dose for the different exposure scenarios considered in this report.

The last conclusion follows from the survey data summarized in Appendixes B and C, which indicate that compliance with the proposed guidelines for residual concentrations of ^{137}Cs in soil would greatly reduce dose rates at locations with the highest concentrations and would substantially reduce the average dose rates in contaminated areas.

5.4 REFINEMENTS OF THE ASSESSMENT

The preliminary analysis presented in this report has indicated that a number of refinements in the assessment could be important in determining needs for remediation of the contamination.

Additional information on potential exposures of railroad workers would be useful, because dose rates experienced by such individuals could exceed those for other members of the public. Potentially important information on railroad workers includes the following:

- exposure times during routine work activities in contaminated areas that do not disturb railroad ties and ballast materials;

- the frequency of repair or replacement of railroad ties and ballast materials in contaminated areas and exposure times during such activities; and

- during repair or replacement of railroad ties and ballast materials in contaminated areas, estimates of gamma exposure rates above ground, deposition of activity on clothing or the body surface, ingestion of activity transferred to the hands, and atmospheric mass loadings of respirable materials.

For members of the public other than railroad workers, the most important source of uncertainty in the analysis that could lead to substantially higher estimates of dose probably is the assumption that the contaminated areas will not revert to public ownership within the next 30 years. However, even if permanent residence on the contaminated land in the near future were possible, the analysis indicates that annual effective dose equivalents to members of the public are unlikely to exceed the limit of 100 mrem (1 mSv) from all sources of exposure in current radiation protection standards for the public.

Information on exposure times at the present time for members of the public other than railroad workers also could be useful for the dose analysis. However, since residence in contaminated areas for a substantial fraction of the time is precluded by private ownership of the land, data on exposure times are not likely to change the conclusion from this analysis that doses to members of the public at the present time are low and are considerably less than the proposed limit of 25 mrem (0.25 mSv) per year for this source of exposure.

Since the proposed guidelines for residual concentrations of ^{137}Cs are potentially important in determining the need for remediation, further evaluation of the volume of material in which the concentrations exceed the guidelines would be useful. Since the available data allow only an uncertain estimate of the affected volumes of material, further sampling probably would be required for this purpose. We particularly noted that relatively high but localized concentrations of ^{137}Cs below the ground surface may not have been detected by means of measured gamma exposure rates at or above the surface.

The proposed guidelines for residual concentrations of ^{137}Cs in areas of widespread and localized contamination developed in this report were only tentative. Guidelines could be derived using procedures specified by DOE (Gilbert et al. 1989). However, the two sets of guidelines probably would not differ significantly, i.e., by more than a factor of 2. Therefore, the development of revised guidelines is not likely to have a significant effect on the volume of contaminated material containing ^{137}Cs concentrations above the guidelines. As discussed above, these guidelines are likely to be more important than estimated doses to railroad workers or other members of the public in determining needs for remediation of the contamination.

Finally, because of the possibility that the total release of ^{137}Cs to the environment exceeded the RQ of 1 Ci (0.04 TBq), a reevaluation of the total release could be useful. As in the case of an evaluation of the concentrations of ^{137}Cs in relation to guidelines for residual contamination, additional sampling may be needed for this purpose.

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Appendix A

LETTER FROM R. D. FOLEY TO J. D. BERGER

OAK RIDGE NATIONAL LABORATORY

OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37831

November 10, 1986

J. D. Berger
Oak Ridge Associated Universities
P. O. Box 117
Oak Ridge, Tennessee 37831

Dear Jim:

Cesium-137 Contamination on Railroad Tracks

The Radiological Survey Activities (RASA) group of Oak Ridge National Laboratory (ORNL) did a preliminary radiological survey of the railroad tracks east of Scarboro Road across from the Y-12 plant (see attached figure). This survey was conducted on June 19, 1986.

The survey began from 601 Scarboro Road and continued in a northerly direction for approximately 50 yards until parked railroad cars were encountered. This part of the survey was terminated at the cars. No contamination was found; however, readings on railroad gravel on both sides of the driveway going into 601 Scarboro were elevated. The gravel was made of what appeared to be granite and contained elevated levels of natural radioactivity. A second area of this same type of stone was found and sampled with similar analytical results.

Beginning again at the 601 Scarboro driveway, the survey was continued for approximately 250 yards to the end of the tracks going in a southeasterly direction. The first anomaly was discovered approximately 75 yards from the starting point. The anomalies continued in "spots" for another 120 yards. A sample was taken at approximately 150 yards which had 2100 ± 9 pCi/g of Cesium-137 (Cs). The sample was taken from 0" to 2" deep. The surface exposure rate was approximately 1 mR/h and increased about 33% at two inches.

At approximately 175 yards from the 601 Scarboro Road driveway, an abandoned railroad spur curved off to the southeast. The connecting switch and rails had been removed. This set of rails continued for some distance, but only the first 50 yards were surveyed. The only contamination found on the spur was near the main tracks. A sample was taken from the contaminated area. The exposure rate at the surface of the ground was about 0.6 mR/h, and the soil sample contained 880 ± 6 pCi/g of ^{137}Cs.

In no case was contamination located beyond the width of a railroad car on either set of rails. No attempt was made to determine the depth to which the contamination may have penetrated. A more extensive survey will be required to determine the areal and vertical dispersion of the ^{137}Cs contamination.

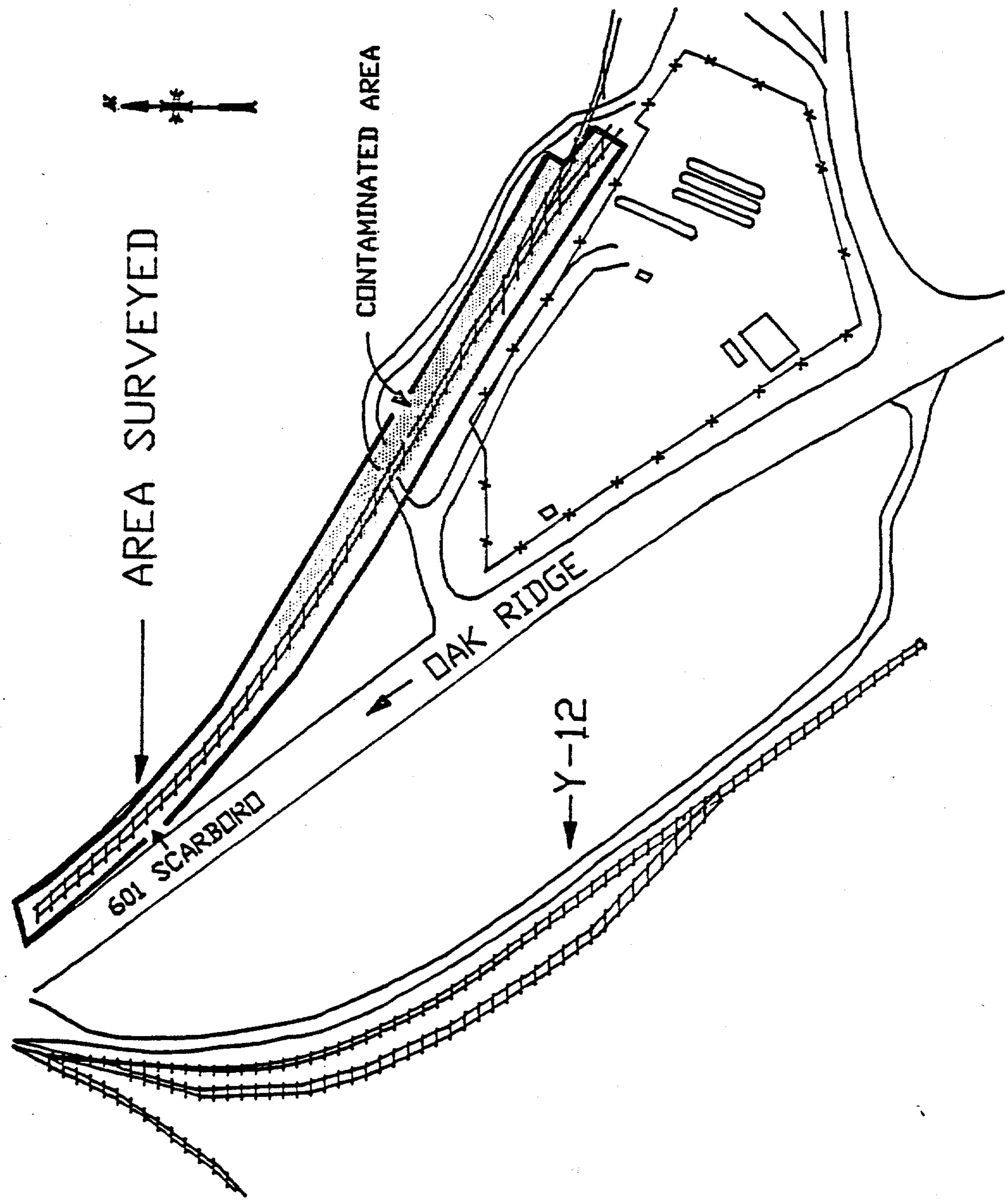
Sincerely yours,

B A Berven for R.D. Foley

Ray D. Foley
Radiological Survey Activities Group

RDF:sh

cc: B. A. Berven
W. D. Cottrell


AREA SURVEYED
CONTAMINATED AREA
OAK RIDGE
601 SCARBORO
Y-12

Appendix B

RADIOLOGICAL SURVEY OF THE RAILROAD TRACKS ADJACENT TO SCARBORO ROAD, OAK RIDGE, TENNESSEE

RADIOLOGICAL SURVEY
OF THE
RAILROAD TRACKS ADJACENT TO SCARBORO ROAD
OAK RIDGE, TENNESSEE

INTRODUCTION

During a June 1986 survey of Y-12 Plant property, Oak Ridge National Laboratory's Radiological Survey Activities group identified cesium 137 contamination along railroad tracks of the CSX Transportation Group, adjacent to Scarboro Road. As a followup on these findings, the Department of Energy's Oak Ridge Operations Office requested that the Radiological Site Assessment Program of Oak Ridge Associated Universities characterize the levels and extent of the contamination. An access agreement for the railroad right-of-way was received in October 1986 and a survey of the area was conducted during November 6 through 19, 1986. The procedures and findings of that survey are presented in this report.

SITE DESCRIPTION

Portions of CSX Transportation Group railroad tracks, covered by this survey, are indicated on Figure 1. The northernmost point is on the east side of Scarboro Road, approximately 70 m north of the intersection of Scarboro Road with Bear Creek Road. The track divides about 40 m south of the starting point. One main section, designated "CSX-East" in this report, continues along the east side of Scarboro Road for a length of 470 m. The remains of a previous rail bed continues beyond the present end of the track, onto Oak Ridge Utility District property. Another spur track previously ran east from the existing track, beginning about 70 m north of the present track terminating point. This section also contains only remnants of the old rail bed.

After the track divides, the other main section crosses to the west side of Scarboro Road and then parallels the road for a length of 370 m. This

This report is based on work by Oak Ridge Associated Universities performed under contract number DE-AC05-76OR00033 with the U.S. Department of Energy.

February 10, 1987

section of track is designated as "CSX-West" for the purpose of this report. One spur track splits off of the main track and continues westward for 110 m, at which point it enters the Y-12 Plant. For approximately 130 m, a siding parallels the main track on the east side.

PROCEDURES

1. For survey measurement and sampling reference, a 10 m grid was established along the centerline of each of the two main track sections (CSX-East and CSX-West). Grid origins and major reference points are shown on Figure 2. All survey activities were recorded relative to these grid systems.

2. Walkover surface gamma scans were conducted at 1 - 2 m intervals along all tracks and rail-bed areas indicated on Figure 2. These scans extended a minimum of 5 m beyond the edge of the tracks and rail beds. Portions of the Oak Ridge Utility District property, adjacent to the tracks and along the old rail bed were also scanned. Gamma scintillation [NaI(Tl)] detectors with portable ratemeters were used for these scans. Locations of elevated contact radiation levels were marked for further investigation.

3. Exposure rates were measured at the surface and at 1 m above the surface, using gamma scintillation detectors. Measurements were at 10 m intervals along the grid centerline, 5 m either side of the centerline at 10 m intervals, and 1 m either side of the centerline at alternating 20 m intervals. Measurements were also made at locations identified by the walkover surface scans. Conversion to exposure rates in microroentgens per hour (μR/h) was determined by onsite cross calibration of the NaI(Tl) detectors with a pressurized ionization chamber. At several locations, the radiation field exceeded the range of the scintillation meter; exposure rates at these locations were measured with an ionization survey meter.

4. Surface (0 - 15 cm) samples of soil and/or ballast were collected 5 m either side of the track centerline at 10 m intervals and 1 m either

side of the centerline at alternating 20 m intervals. Samples were also collected at representative locations of elevated contact radiation, identified by walkover surface scans.

5. Subsurface samples were collected at representative locations, identified by walkover gamma scans. The maximum depth of sampling was 105 cm. Subsurface samples were also collected at two locations of ambient radiation readings. These subsurface sampling locations are shown on Figure 3.

6. Two sediment samples and two water samples were collected from a stream crossed by the tracks (Figure 4).

7. Soil, ballast, and sediment samples were analyzed by solid state gamma spectrometry techniques. Based on Oak Ridge National Laboratory findings, the major radionuclide of concern was Cs-137; however, the spectra were reviewed for other identifiable photopeaks. Four soil samples were also analyzed for strontium 89/90 using wet chemistry techniques. Water samples were analyzed for gross alpha and gross beta concentrations.

RESULTS

1. Walkover Surface Scans

The walkover scans identified multiple isolated spots and general areas of elevated contact gamma radiation along the tracks. These locations are shown of Figure 5. With only a few exceptions, these locations are within 1 m of the track centerline. No elevated radiation levels were noted on the Oak Ridge Utility District property or along the section of track leading into the Y-12 Plant. Contamination was identified near the junction of the CSX-East track with the old rail bed and at several locations adjacent to the rail bed; there were no locations noted on the rail bed itself.

2. Exposure Rates

Gamma exposure rates, measured at 10 and 20 m intervals along the tracks are presented in Tables 1 and 2. On the tracks east of Scarboro Road the exposure rates ranged from 7 to 14 μR/h at contact and from 7 to 13 μR/h at 1 meter above the surface. Along the old rail bed the rates ranged from 6 to 11 μR/h at contact and from 6 to 9 μR/h at 1 m above the surface. Exposure rates ranged from 7 to 10 μR/h, at both contact and at 1 m above the surface, at 10 and 20 m intervals along tracks on the west side of Scarboro Road. For comparison purposes, the background exposure rate in the Oak Ridge, Tennessee area typically ranges from about 6 to 12 μR/h.

Radiation levels associated with locations identified by the walkover gamma scans are presented in Tables 3 and 4, for the CSX-East and CSX-West areas, respectively. On the east side, the exposure rates ranged from 15 to 430 μR/h at contact and 10 to 25 μR/h at 1 m above the surface; on the west side, the exposure rate ranges were 16 to 480 μR/h at contact and 10 to 130 μR/h at 1 m above the surface.

3. Radionuclide Concentrations in Soil and Ballast Samples

Tables 5 and 6 present the Cs-137 concentrations measured in surface samples of soil and ballast from 10 and 20 m intervals along the tracks. Concentrations ranged from <0.1 pCi/g to 26 pCi/g; with few exceptions, the Cs-137 concentrations were within the range typically present in baseline surface soil from the Oak Ridge area, i.e. approximately 0.1 to 2.0 pCi/g.

Cesium 137 concentrations in surface and subsurface samples from representative locations of elevated contact gamma radiation are presented in Tables 7 and 8. These samples contained up to 2800 pCi/g on the CSX-East area and up to 16,000 pCi/g on the CSX-West areas. The contamination was primarily within the upper 30 cm of ballast or soil plus ballast. At two locations (boreholes 11 and 14 on CSX-East) sampling continued through the ballast into the underlying soil. Results of this sampling indicate that only a small fraction of the contamination has migrated downward into the soil layer. Examination of several of the samples containing higher Cs-137 levels indicates that the contamination is in the form of surface contamination on pieces of ballast and distributed throughout dirt fines collected with the ballast. Samples did not contain the contaminant in single, discrete sources.

Gamma spectra did not identify the presence of other gamma-emitting radionuclides at concentrations outside the background ranges, typically encountered in the Oak Ridge area. For both uranium 238 and thorium 232, these background ranges are approximately 0.5 to 2 pCi/g.

The four samples analyzed for strontium 89/90 contained less than the minimum detectable concentrations, i.e., <0.5 to <1.2 pCi/g. Two reference locations with direct radiation levels typical of the Oak Ridge area (locations 18 and 19 on Figure 3 and Table 7), had Cs-137 concentrations in the range of normal baseline samples.

4. Radionuclide Concentrations in Stream Samples

Table 9 presents the radionuclide concentrations measured in water and sediment samples from the small drainage stream crossed by the tracks. Water concentrations were 2.3 and 2.6 pCi/l gross alpha and 5.4 pCi/l gross beta. Sediment samples contained <0.1 and 0.3 pCi/g of Cs-137. These values are typical of levels normally occurring in baseline water and sediment.

SUMMARY

A survey of the CSX Transportation Group railroad right-of-way areas, adjacent to Scarboro Road near the Y-12 Plant, was performed by Oak Ridge Associated Universities, between November 6 - 19, 1986. The survey results indicate the presence of elevated gamma radiation levels and Cs-137 contaminated ballast and soil at small, isolated locations and larger general areas along the railroad tracks. The contamination is predominantly within the upper 30 cm of ballast and soil; with few exceptions, it is limited to the area within 1 m of the track centerline.

The maximum direct gamma radiation level at 1 m above the surface is 130 μR/h and Cs-137 concentrations range up to 16,000 pCi/g. The Department of Energy (DOE) has not established a specific guideline for Cs-137 contamination in soils of unrestricted areas; however, the Nuclear Regulatory Commission (NRC) has used a guidance level of 17 pCi/g for sites being release from licensing controls. For direct radiation, assuming unlimited occupancy time, an exposure rate exceeding 11.4 μR/h above the background level could result in doses above the recently proposed DOE and NRC dose limits of 100 mrem/y for continuing exposure of the general public. Although the soil concentrations and direct radiation levels along the track exceed the above guidelines, the current uses of the contaminated area, make it unlikely that members of the public would exceed dose limits. There also is no indication that the contamination is migrating from its present locations.

Based on an average width of 2 m and and average depth of 30 cm it is estimated that the volume of ballast and soil exceeding the NRC's 17 pCi/g guideline concentration for Cs-137 is approximately 180 m^3.

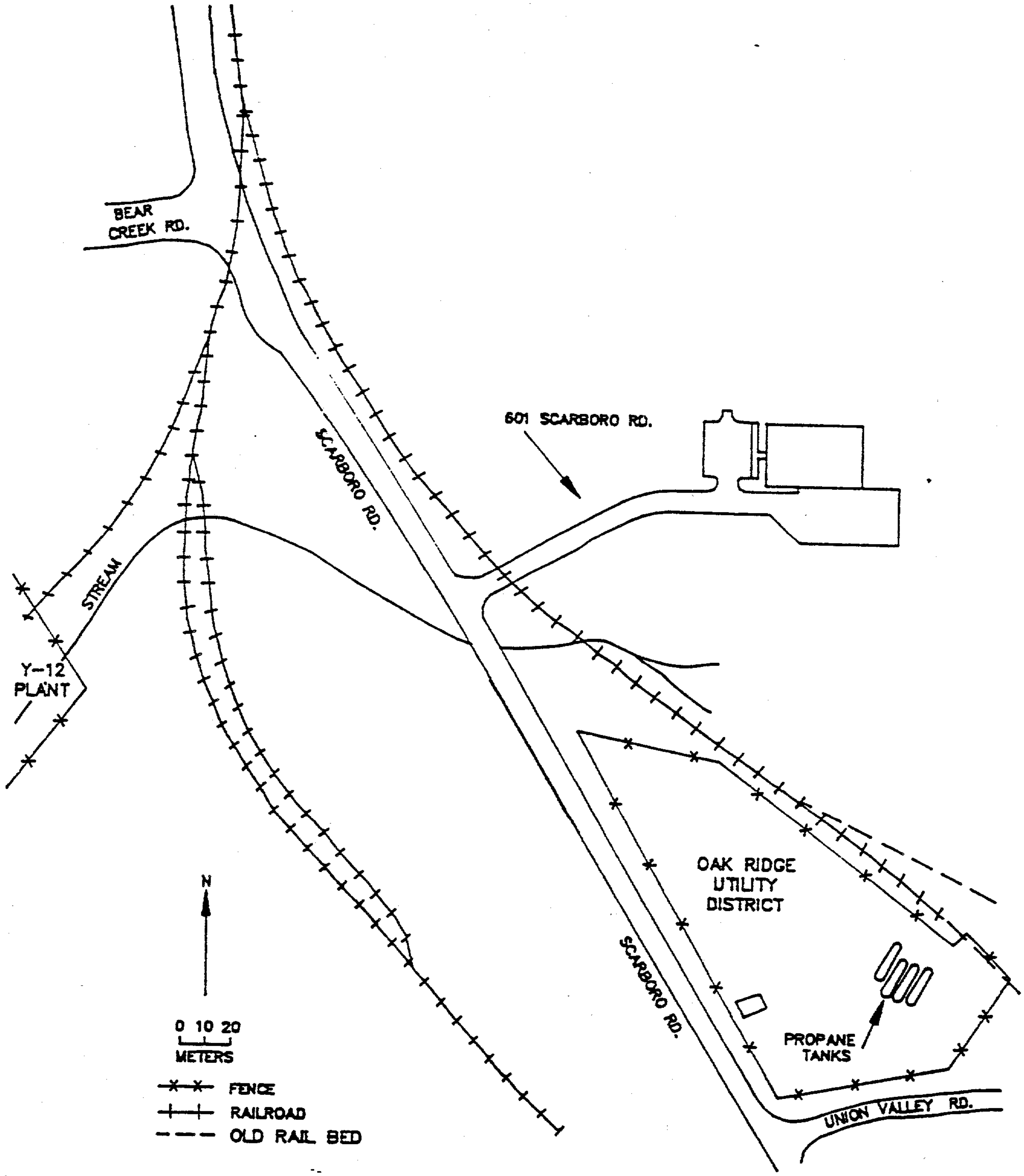


FIGURE 1: Plot Plan of the CSX Transport Group Railroad Tracks Near the Y-12 Plant

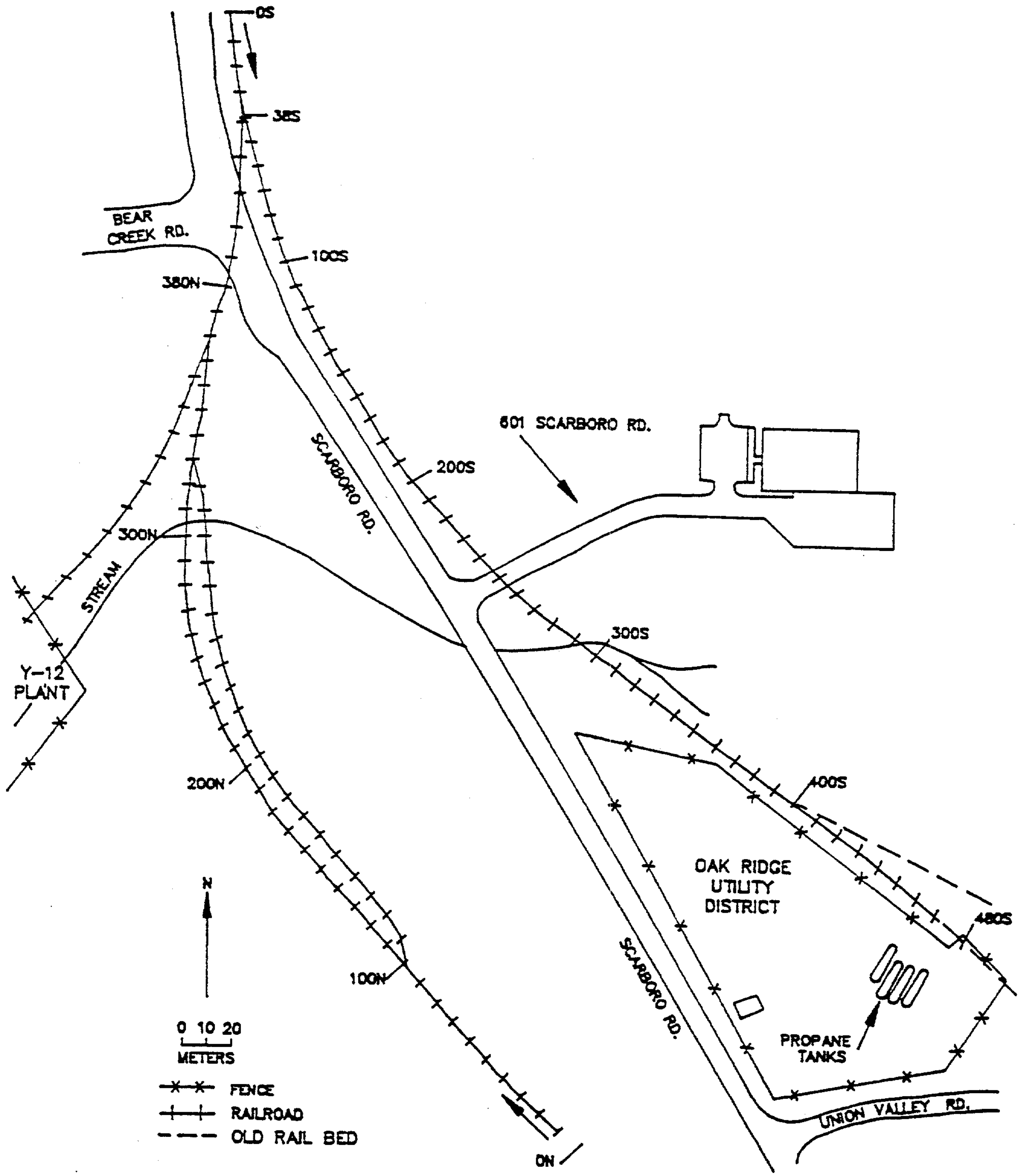


FIGURE 2: Grid Systems Established for Survey Reference

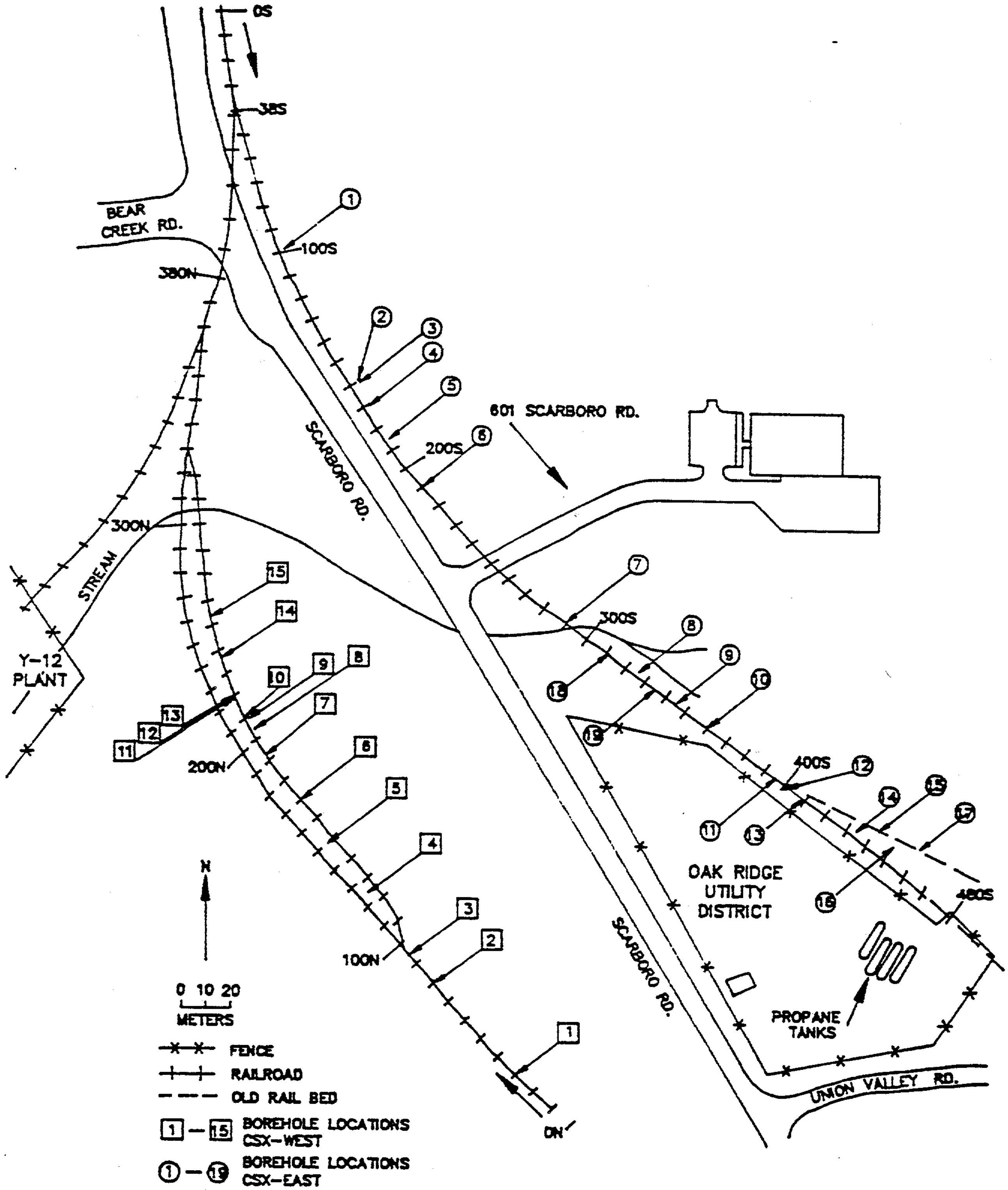


FIGURE 3: Locations of Subsurface Sampling

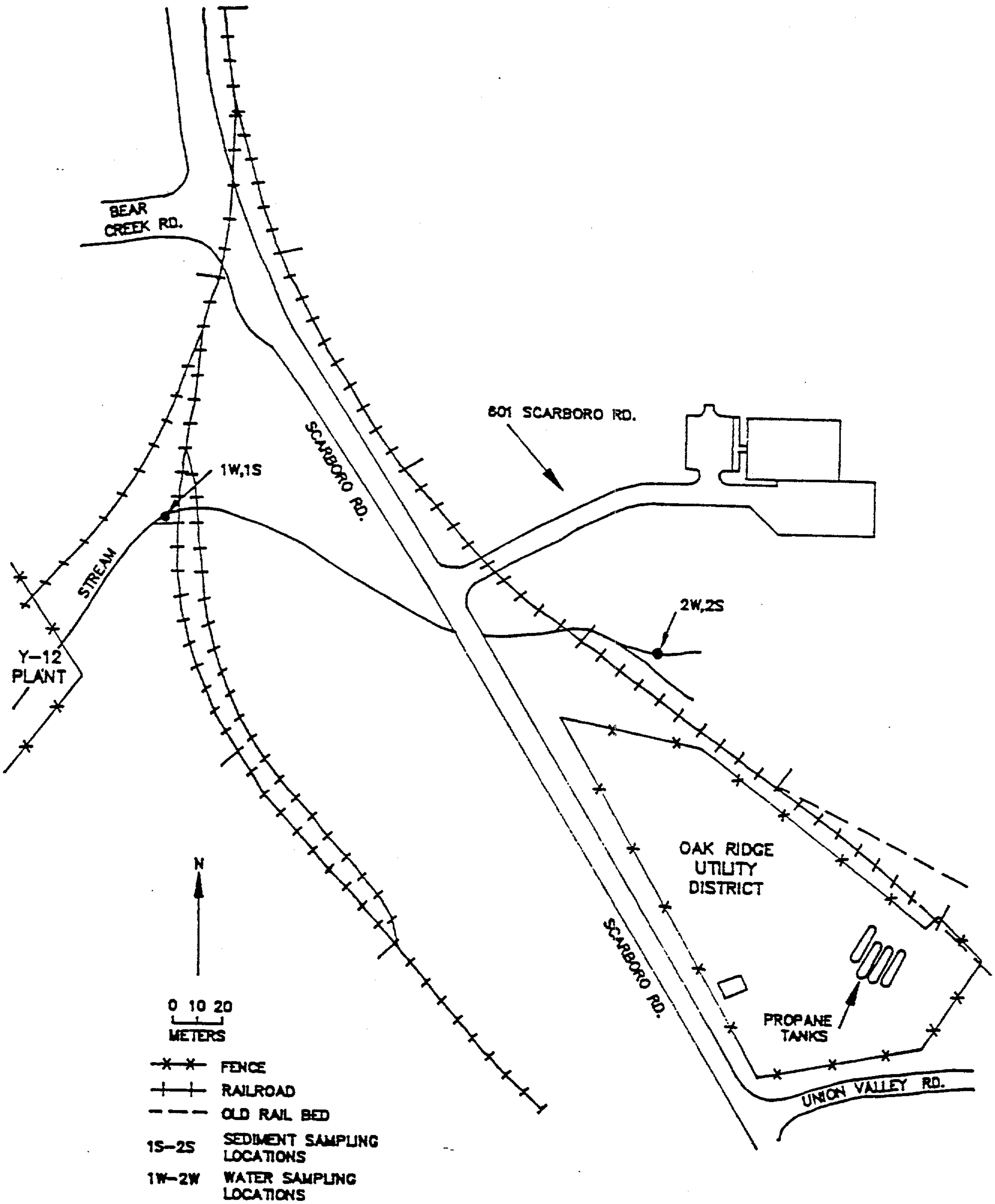


FIGURE 4: Locations of Water and Sediment Sampling

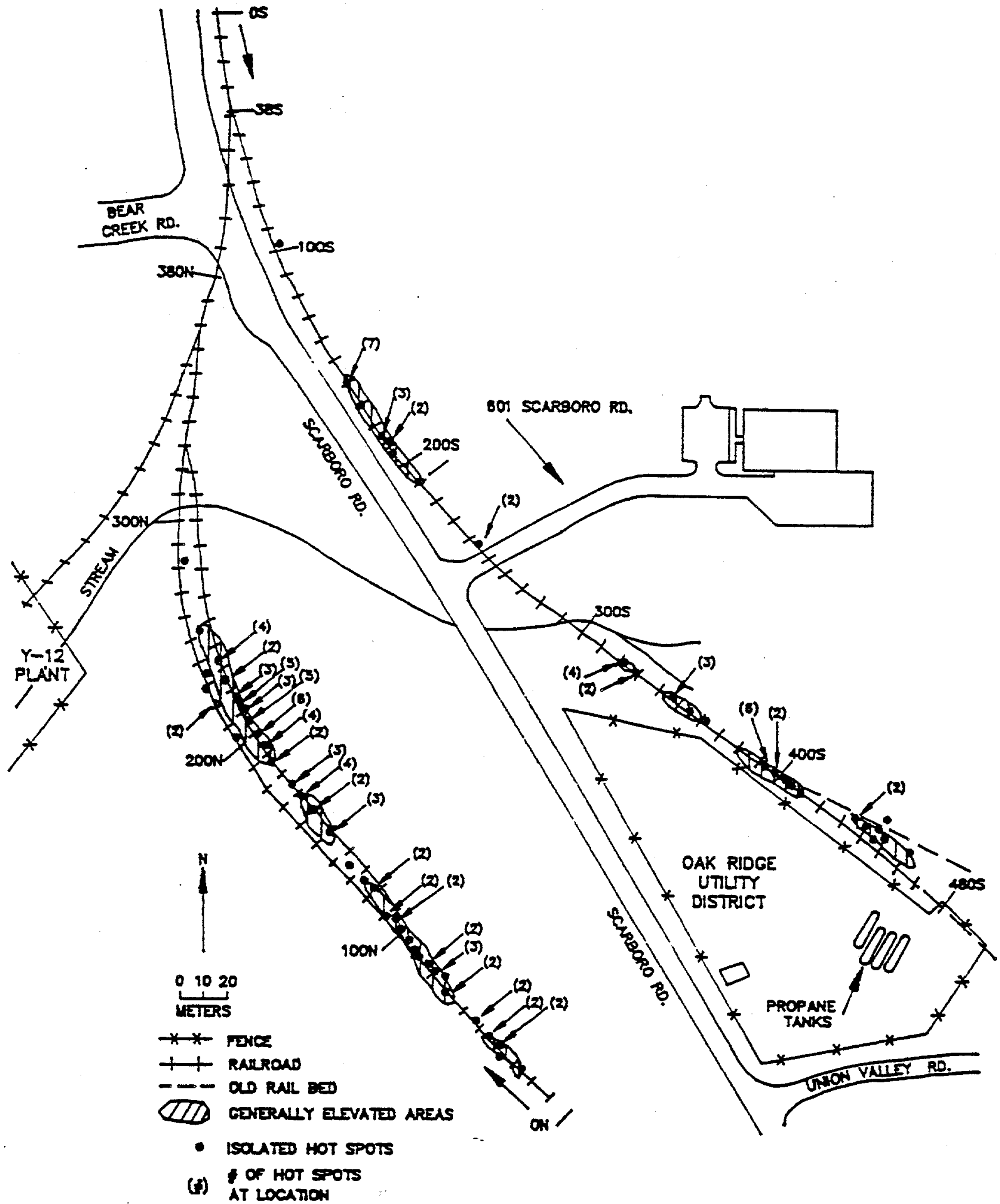


FIGURE 5: Locations of Elevated Gamma Radiation Identified by Walkover Scans

TABLE 1

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid[a] Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
MAIN TRACK		
0S,5W	10	10
0S,0	10	8
0S,1E	10	11
0S,5E	13	13
10S,5W	11	11
10S,1W	11	10
10S,0	10	11
10S,5E	13	13
20S,5W	11	12
20S,0	10	10
20S,1E	11	10
20S,5E	12	13
30S,5W	10	12
30S,1W	10	10
30S,0	10	10
30S,5E	12	13
40S,5W	10	9
40S,0	10	9
40S,1E	11	10
40S,5E	13	13
50S,5W	10	10
50S,1W	10	10
50S,0	10	10
50S,5E	12	13
60S,5W	11	11
60S,0	10	11
60S,1E	11	12
60S,5E	13	13
70S,5W	11	11
70S,1W	10	11
70S,0	11	10
70S,5E	13	13
80S,5W	11	12
80S,0	11	11
80S,1E	11	12
80S,5E	13	13
90S,5W	11	12
90S,1W	10	11
90S,0	11	10
90S,5E	13	13
100S,5W	12	12
100S,0	12	11

TABLE 1 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
100S,1E	14	12
100S,5E	13	13
110S,5W	11	11
110S,1W	10	11
110S,0	11	11
110S,5E	13	13
120S,5W	12	12
120S,0	11	11
120S,1E	11	13
120S,5E	13	13
130S,5W	11	11
130S,1W	11	12
130S,0	11	11
130S,5E	12	13
140S,5W	11	10
140S,0	11	10
140S,1E	11	11
140S,5E	13	13
150S,5W	11	11
150S,1W	10	11
150S,0	10	11
150S,5E	13	13
160S,5W	11	11
160S,0	12	11
160S,1E	11	12
160S,5E	13	13
170S,5W	11	10
170S,1W	11	10
170S,0	11	11
170S,5E	13	13
180S,5W	11	11
180S,0	11	11
180S,1E	11	11
180S,5E	13	13
190S,5W	11	11
190S,1W	12	12
190S,0	11	11
190S,5E	12	13
200S,5W	11	12
200S,0	11	11
200S,1E	10	11
200S,5E	12	12
210S,5W	12	12

TABLE 1 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
210S,1W	11	11
210S,0	11	11
210S,5E	11	12
220S,5W	12	12
220S,0	11	11
220S,1E	11	11
220S,5E	11	11
230S,5W	13	13
230S,1W	12	13
230S,0	12	12
230S,5E	12	12
240S,5W	11	12
240S,0	13	15
240S,1E	13	15
240S,5E	12	12
250S,5W	10	9
250S,1W	10	10
250S,0	10	9
250S,5E	10	10
260S,5W	12	12
260S,0	12	12
260S,1E	13	13
260S,5E	11	11
270S,5W	12	13
270S,1W	11	11
270S,0	11	12
270S,5E	11	11
280S,5W	12	12
280S,0	11	11
280S,1E	12	11
280S,5E	12	12
290S,5W	11	12
290S,1W	11	11
290S,0	11	10
290S,5E	11	12
300S,5W	12	12
300S,0	10	10
300S,1E	11	11
300S,5E	12	12
310S,5W	11	11
310S,1W	11	10
310S,0	10	10
310S,5E	12	12

TABLE 1 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
320S,5W	11	11
320S,0	10	10
320S,1E	11	11
320S,5E	11	11
330S,5W	10	10
330S,1W	9	8
330S,0	9	7
330S,5E	10	11
340S,5W	10	10
340S,0	8	8
340S,1E	9	8
340S,5E	10	10
350S,5W	10	10
350S,1W	9	9
350S,0	10	8
350S,5E	11	11
360S,5W	11	11
360S,0	10	11
360S,1E	10	9
360S,5E	11	11
370S,5W	11	11
370S,1W	9	8
370S,0	8	7
370S,5E	10	11
380S,5W	10	11
380S,0	8	8
380S,1E	10	8
380S,5E	10	10
390S,5W	10	11
390S,1W	10	8
390S,0	9	7
390S,5E	10	10
400S,5W	10	10
400S,0	10	10
400S,1E	10	10
400S,5E	10	11
410S,5W	9	8
410S,1W	9	8
410S,0	8	8
410S,5E	10	10
420S,5W	9	10
420S,0	8	8
420S,1E	9	9

TABLE 1 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
420S,5E	9	10
430S,5W	9	10
430S,1W	9	7
430S,0	9	8
430S,5E	9	10
440S,5W	10	10
440S,0	9	8
440S,1E	8	8
440S,5E	11	10
450S,5W	9	8
450S,1W	7	7
450S,0	7	8
450S,5E	7	7
460S,5W	8	7
460S,0	7	6
460S,1E	7	7
460S,5E	8	9
470S,5W	7	7
470S,1W	8	8
470S,0	7	7
470S,5E	8	9
480S,5E	10	10
480S,1E	8	8
480S,0	7	7
OLD RAIL BED		
420S,10E	9	8
430S,10E	9	9
440S,10E	9	11
450S,10E	7	7
460S,10E	6	8
460S,15E	7	7
470S,10E	8	6
470S,15E	8	7
480S,10E	8	10
480S,15E	8	7

[a]Refer to Figure 2.

TABLE 2

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid[a] Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
0N,5W	11	11
0N,0	11	10
0N,5E	11	11
10N,5W	11	11
10N,1W	8	8
10N,0	9	9
10N,5E	10	10
20N,5W	10	10
20N,0	10	10
20N,1E	9	10
20N,5E	10	10
30N,5W	10	10
30N,1W	10	10
30N,0	11	11
30N,5E	11	10
40N,5W	10	11
40N,0	9	8
40N,1E	8	10
40N,5E	10	10
50N,5W	11	11
50N,1W	10	8
50N,0	9	8
50N,5E	9	10
60N,5W	11	11
60N,0	10	10
60N,1E	10	9
60N,5E	10	10
70N,5W	11	11
70N,1W	11	11
70N,0	11	11
70N,5E	10	10
80N,5W	10	10
80N,0	18	13
80N,1E	15	13
80N,5E	10	10
90N,5W	11	11
90N,1W	12	11
90N,0	19	13
90N,5E	10	10
100N,5W	11	10
100N,0	16	19
100N,1E	15	19

TABLE 2 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
100N,5E	11	11
110N,5W	11	11
110N,1W	10	10
110N,0	10	10
110N,5E	10	11
120N,5W	11	11
120N,0	10	10
120N,1E	11	10
120N,5E	11	10
120N,10E	10	10
130N,5W	11	11
130N,1W	10	10
130N,0	10	10
130N,5E	8	8
130N,10E	10	10
140N,5W	10	11
140N,0	10	9
140N,5E	10	10
140N,10E	10	10
150N,5W	11	11
150N,0	10	9
150N,5E	10	9
150N,10E	10	10
160N,5W	11	10
160N,0	8	10
160N,5E	10	7
160N,10E	10	10
170N,5W	10	11
170N,0	10	10
170N,5E	19	12
170N,10E	17	14
180N,5W	10	10
180N,0	10	10
180N,5E	9	10
180N,10E	11	10
190N,5W	10	10
190N,0	10	11
190N,5E	12	10
190N,10E	13	13
200N,5W	10	10
200N,0	10	10
200N,5E	10	10
200N,10E	15	17

TABLE 2 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (µR/h)	Gamma Exposure Rates at the Surface (µR/h)
200N,15E	11	11
210N,5W	7	8
210N,0	10	10
210N,5E	11	10
210N,10E	13	11
210N,15E	11	10
220N,5W	8	8
220N,0	11	11
220N,5E	10	10
220N,10E	11	11
220N,15E	10	10
230N,5W	11	11
230N,0	10	10
230N,5E	9	8
230N,10E	11	11
230N,15E	10	10
240N,5W	10	10
240N,0	9	10
240N,5E	10	10
240N,10E	13	13
240N,15E	9	9
250N,5W	10	10
250N,0	10	9
250N,5E	8	8
250N,10E	8	9
250N,15E	9	9
260N,5W	9	10
260N,0	10	8
260N,5E	9	8
260N,10E	8	8
260N,15E	9	10
270N,5W	11	11
270N,0	9	7
270N,5E	8	8
270N,10E	9	9
280N,5W	11	11
280N,0	10	9
280N,5E	8	8
280N,10E	10	10
290N,5W	11	11
290N,0	9	8
290N,5E	9	7
290N,10E	10	10

TABLE 2 (Continued)

EXPOSURE RATES MEASURED AT 10 AND 20 METER GRID INTERVALS
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
300N,5W	11	12
300N,0	9	9
300N,5E	9	7
300N,10E	10	10
310N,5W	10	10
310N,0	8	8
310N,5E	9	8
310N,10E	9	10
320N,5W	10	11
320N,0	10	8
320N,1E	9	8
320N,5E	10	10
330N,5W	8	8
330N,1W	9	8
330N,0	7	8
330N,5E	10	11
340N,5W	10	10
340N,0	9	7
340N,1E	9	7
340N,5E	10	11
350N,5W	10	10
350N,1W	9	9
350N,0	9	8
350N,5E	11	11
360N,5W	11	12
360N,0	9	8
360N,1E	9	8
360N,5E	10	11
370N,5W	11	11
370N,1W	10	9
370N,0	9	8
370N,5E	10	10
380N,5W	8	8
380N,0	8	8
380N,1E	9	9
380N,5E	11	11

[a]Refer to Figure 2.

TABLE 3

EXPOSURE RATES MEASURED AT LOCATIONS IDENTIFIED BY WALKOVER SCANS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location[a]	Exposure Rate (μR/h)		Contact Exposure Rate[b] After Sample Removal (μR/h)
	Contact	1 m Above Surface	
99S,1E	190	23	230
157.5S,0.5E	28	–[c]	–
158S,0.5E	28	11	–
158.5S,0.5E	51	–	–
159S,0.5E	49	11	67
159.5S,0.5E	34	11	–
160.5S,0.5W	25	11	44
160.5S,0.5E	38	11	–
170S,1E	56	13	150
183S,0.8E	110	–	–
183S,1E	120	16	–
185S,0.5E	21	12	–
188S,0.8E	130	–	–
188S,1E	200	15	210
190.5S,0.5E	15	–	–
209.5S,0.5E	26	–	–
243S,0	17	–	–
243S,0.3E	19	14	–
289.5S,1E	30	–	–
321S,0.5E	19	–	–
322S,0.5E	38	11	55
322.5S,0.5W	32	–	–
322.5S,0.5E	36	–	–
325S,0.5W	34	–	–
325S,0.5E	26	–	–
343S,0.5E	19	–	–
344S,0.5E	26	–	–
345S,0.5W	26	–	–
354S,0.5E	30	11	42
360.5S,0.5W	33	11	59
392S,1W	59	–	–
393S,1W	42	–	–
394S,0.3W	430	25	430
394S,1E	69	–	–
395.5S,0	69	–	–
395.5S,1E	90	–	–
397S,0	90	–	–
397S,1E	49	–	–
398S,1E	69	–	–
399S,1E	80	13	100
402S,0.5E	18	–	–
406.5S,1E	19	–	–

TABLE 3 (Continued)
EXPOSURE RATES MEASURED AT LOCATIONS IDENTIFIED BY WALKOVER SCANS
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Exposure Rate (μR/h)		Contact Exposure Rate After Sample Removal (μR/h)
	Contact	1 m Above Surface	
409S,1E	69	14	90
433S,4E	260	20	380
433S,4.5E	240	-	-
437S,5E	38	-	-
441S,5E	36	-	-
441S,6E	64	13	120
441S,9E	26	-	-
448S,6E	28	11	40
457S,9E	24	10	27

[a]Refer to Figure 5.
[b]Cs-137 concentrations of selected samples are presented in Table 7.
[c]Dash indicates measurement not performed.

TABLE 4

EXPOSURE RATES MEASURED AT LOCATIONS IDENTIFIED BY WALKOVER SCANS
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location[a]	Exposure Rate (μR/h)		Contact Exposure Rate[b] After Sample Removal (μR/h)
	Contact	1 m Above Surface	
19.5N,1W	25	10	– [c]
28N,2W	17	11	–
30N,0.5W	59	11	49
31.5N,0.5E	43	13	–
37N,1W	32	11	–
37N,1E	130	13	–
44N,1W	90	17	–
45N,0.5W	54	17	–
70N,0.5W	40	12	–
72N,0.5W	69	13	–
79.5N,0.75E	16	15	20
81N,1E	390	30	–
81.5N,1W	110	25	–
82N,1E	280	30	–
84N,1W	75	18	–
84N,1E	280	21	–
87N,1E	47	13	–
91N,0.5E	280	32	–
94N,2E	130	15	470
100.5N,0.5E	80	17	–
103N,0.5E	51	14	–
104.5N,1E	69	14	–
109.5N,1.5E	30	11	–
111N,2E	95	15	–
120N,2.5E	90	15	–
121.5N,4E	59	14	–
128N,3E	26	13	19
137N,3E	28	11	–
151N,4.5E	44	13	–
151N,6E	23	13	35
152N,6E	35	11	–
160N,6E	69	12	–
162N,6E	17	10	–
169N,6.5E	170	32	–
170N,1E	17	10	–
170.5N,7E	480	130	560
171.5N,9E	130	38	–
175N,9E	46	17	–
176N,7E	75	13	–
177N,9E	36	14	–
189.5N,8.5E	360	23	–
190.5N,7E	44	23	–

TABLE 4 (Continued)
EXPOSURE RATES MEASURED AT LOCATIONS IDENTIFIED BY WALKOVER SCANS
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location	Exposure Rate (μR/h) Contact	1 m Above Surface	Contact Exposure Rate After Sample Removal (μR/h)
193N,5E	490	36	-
193N,7.5E	460	150	-
193N,9E	310	69	160
194N,9.5E	150	29	-
199.5N,10E	32	15	-
200N,7E	42	16	-
200N,8E	90	19	-
202N,9.5E	28	16	-
202.5N,7E	150	30	210
202.5N,8E	57	20	-
206N,6.5E	120	21	-
206N,8.5E	224	38	-
206N,0.5W	31	10	-
208N,7E	100	16	-
208.5N,10E	19	14	-
209N,11E	30	14	24
210.5N,8.5E	100	15	-
212N,7E	30	13	-
212.5N,8.5E	110	14	-
215N,0.5E	42	15	-
215N,8.5E	32	12	-
215N,7E	23	11	-
217.5N,6.5E	28	12	-
217.5N,7.5E	69	13	69
219N,7E	21	12	-
220N,7.5E	49	12	90
221N,1E	41	11	-
221N,7.5E	38	12	-
221N,0.5W	42	11	31
222.5N,7E	25	13	-
222.5N,8E	43	13	-
227N,8E	130	15	-
229N,9E	85	13	-
230N,0.5W	17	11	-
235N,1E	66	14	-
239.5N,10E	28	15	24
240N,7E	33	12	-
240N,8E	69	14	-
241N,7.5E	64	14	-
252.5N,3E	33	13	13
280.5N,1E	19	10	-

[a] Refer to Figure 5.
[b] Cs-137 concentrations of selected samples are presented in Table 8.
[c] Dash indicates measurement not performed.

TABLE 5

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location[a]		Cs-137 (pCi/g)
MAIN TRACK		
0S	5W	0.8 ± 0.2[b]
	1E	0.8 ± 0.2
	5E	1.4 ± 0.2
10S	5W	<0.1
	1W	1.1 ± 0.2
	5E	0.8 ± 0.1
20S	5W	1.0 ± 0.2
	1E	0.4 ± 0.1
	5E	0.8 ± 0.2
30S	5W	<0.1
	1W	0.3 ± 0.1
	5E	0.5 ± 0.1
40S	5W	1.1 ± 0.2
	1E	1.4 ± 0.2
	5E	1.7 ± 0.2
50S	5W	1.1 ± 0.1
	1W	0.5 ± 0.2
	5E	0.7 ± 0.2
60S	5W	0.2 ± 0.1
	1E	0.7 ± 0.2
	5E	0.9 ± 0.2
70S	5W	0.4 ± 0.1
	1W	0.4 ± 0.1
	5E	0.9 ± 0.2
80S	5W	0.3 ± 0.1
	1E	0.5 ± 0.3
	5E	0.6 ± 0.1
90S	5W	0.4 ± 0.1
	1W	0.5 ± 0.2
	5E	<0.1
100S	5W	0.4 ± 0.1
	1E	0.7 ± 0.2
	5E	0.8 ± 0.2
110S	5W	<0.1
	1W	0.3 ± 0.1
	5E	0.5 ± 0.2
120S	5W	0.4 ± 0.1
	1E	0.8 ± 0.3
	5E	<0.1

TABLE 5 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location		Cs-137 (pCi/g)
130S	5W	<0.1
	1W	0.7 ± 0.3
	5E	1.3 ± 0.3
140S	5W	0.1 ± 0.1
	1E	0.5 ± 0.3
	5E	0.8 ± 0.2
150S	5W	0.1 ± 0.1
	1W	0.4 ± 0.2
	5E	1.6 ± 0.3
160S	5W	0.1 ± 0.1
	1E	0.5 ± 0.3
	5E	0.8 ± 0.2
170S	5W	0.1 ± 0.1
	1W	0.7 ± 0.2
	5E	0.6 ± 0.1
180S	5W	<0.1
	1E	1.6 ± 0.4
	5E	1.4 ± 0.2
190S	5W	1.1 ± 0.3
	1W	0.7 ± 0.2
	5E	1.1 ± 0.2
200S	5W	1.0 ± 0.2
	1E	<0.1
	5E	<0.1
210S	5W	1.2 ± 0.2
	1W	0.9 ± 0.3
	5E	0.7 ± 0.2
220S	5W	<0.1
	1E	1.5 ± 0.4
	5E	0.9 ± 0.2
230S	5W	1.0 ± 0.2
	1W	0.7 ± 0.2
	5E	<0.1
240S	5W	<0.1
	1E	<0.1
	5E	0.9 ± 0.2
260S	5W	0.8 ± 0.2
	1E	0.6 ± 0.2
	5E	1.4 ± 0.2
270S	5W	0.6 ± 0.1
	1W	<0.1
	5E	1.0 ± 0.2

TABLE 5 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location		Cs-137 (pCi/g)
280S	5W	0.3 ± 0.1
	1E	0.6 ± 0.3
	5E	1.1 ± 0.3
290S	5W	0.8 ± 0.2
	1W	4.9 ± 0.5
	5E	1.5 ± 0.2
300S	5W	0.8 ± 0.1
	1E	1.8 ± 0.3
	5E	1.2 ± 0.2
310S	5W	0.5 ± 0.3
	1W	0.8 ± 0.2
	5E	1.9 ± 0.2
320S	5W	0.4 ± 0.1
	1E	0.8 ± 0.2
	5E	0.7 ± 0.2
330S	5W	0.3 ± 0.1
	1W	0.4 ± 0.2
	5E	0.3 ± 0.1
340S	5W	0.6 ± 0.2
	1E	<0.1
	5E	<0.1
350S	5W	1.7 ± 0.3
	1W	0.2 ± 0.1
	5E	1.5 ± 0.2
360S	5W	2.0 ± 0.3
	1E	0.5 ± 0.2
	5E	1.0 ± 0.2
370S	5W	1.5 ± 0.3
	1W	0.6 ± 0.2
	5E	0.2 ± 0.1
380S	5W	1.1 ± 0.2
	1E	0.6 ± 0.2
	5E	0.8 ± 0.2
390S	5W	0.7 ± 0.1
	1W	0.6 ± 0.2
	5E	1.0 ± 0.2
400S	5W	0.6 ± 0.1
	1E	2.1 ± 0.3
	5E	1.3 ± 0.2
410S	5W	0.5 ± 0.1
	1W	0.5 ± 0.2
	5E	1.2 ± 0.3

TABLE 5 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location		Cs-137 (pCi/g)
420S	5W	0.7 ± 0.2
	1E	0.6 ± 0.2
	5E	0.4 ± 0.2
430S	5W	0.6 ± 0.1
	1W	0.8 ± 0.2
	5E	0.6 ± 0.1
440S	5W	1.0 ± 0.1
	1E	<0.1
	5E	3.6 ± 0.3
450S	5W	0.5 ± 0.1
	1W	0.6 ± 0.2
	5E	1.7 ± 0.2
460S	5W	0.9 ± 0.2
	1E	1.0 ± 0.2
	5E	2.6 ± 0.3
470S	5W	0.7 ± 0.1
	1W	0.2 ± 0.1
	5E	0.6 ± 0.1
480S	1E	0.8 ± 0.1
	5E	<0.1
OLD RAIL BED		
420S	10E	0.8 ± 0.2
430S	10E	2.6 ± 0.3
440S	10E	8.6 ± 0.6
450S	10E	1.0 ± 0.2
460S	10E	0.8 ± 0.2
	15E	0.6 ± 0.1
470S	10E	0.3 ± 0.1
	15E	0.2 ± 0.1
480S	10E	<0.1
	15E	<0.1

[a]Refer to Figure 2.
[b]Errors are 2σ based only on counting statistics.

TABLE 6

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location[a]		Cs-137 (pCi/g)
0N	5W	<0.1
	0	0.5 ± 0.2[b]
	5E	1.2 ± 0.5
10N	5W	0.7 ± 0.2
	1W	1.2 ± 0.3
	5E	0.3 ± 0.2
20N	5W	0.4 ± 0.2
	1E	3.8 ± 0.3
	5E	0.7 ± 0.1
30N	5W	0.5 ± 0.1
	1W	1.4 ± 0.2
	5E	1.2 ± 0.2
40N	5W	0.4 ± 0.1
	1E	1.6 ± 0.2
	5E	0.7 ± 0.1
50N	5W	0.7 ± 0.2
	1W	0.7 ± 0.1
	5E	0.4 ± 0.1
60N	5W	<0.1
	1E	1.1 ± 0.2
	5E	0.4 ± 0.2
70N	5W	0.6 ± 0.2
	1W	8.1 ± 0.4
	5E	0.9 ± 0.2
80N	5W	0.9 ± 0.1
	1E	11 ± 1
	5E	1.1 ± 0.2
90N	5W	0.6 ± 0.2
	1W	0.5 ± 0.2
	5E	0.9 ± 0.1
100N	5W	0.5 ± 0.1
	5E	9.3 ± 0.4
110N	5W	1.3 ± 0.2
	5E	3.8 ± 0.3
120N	5W	0.5 ± 0.1
	5E	0.7 ± 0.2
	10E	<0.1
130N	5W	0.5 ± 0.1
	5E	0.5 ± 0.1
	10E	0.2 ± 0.1

TABLE 6 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location[a]		Cs-137 (pCi/g)
140N	5W	0.5 ± 0.1
	5E	2.5 ± 0.3
	10E	<0.1
150N	5W	1.4 ± 0.2
	5E	0.7 ± 0.2
	10E	1.1 ± 0.1
160N	5W	0.8 ± 0.2
	5E	0.6 ± 0.2
	10E	1.3 ± 0.2
170N,	5W	0.4 ± 0.1
	5E	0.7 ± 0.1
	10E	2.4 ± 0.2
180N	5W	0.5 ± 0.1
	5E	0.8 ± 0.2
	10E	8.0 ± 0.4
190N	5W	0.8 ± 0.2
	5E	2.1 ± 0.2
	10E	3.7 ± 0.3
200N	5W	0.7 ± 0.1
	5E	1.2 ± 0.3
	10E	26 ± 1
	15E	0.2 ± 0.1
210N	5W	0.1 ± 0.1
	5E	1.2 ± 0.2
	10E	3.2 ± 0.2
	15E	0.9 ± 0.1
220N	5W	0.7 ± 0.1
	5E	1.5 ± 0.2
	10E	2.8 ± 2.2
	15E	0.5 ± 0.1
230N	5W	1.5 ± 0.2
	5E	0.3 ± 0.1
	10E	11 ± 1
	15E	0.3 ± 0.1
240N	5W	1.5 ± 0.2
	5E	4.9 ± 0.3
	10E	2.2 ± 0.2
	15E	0.2 ± 0.1
250N	5W	1.7 ± 0.3
	5E	<0.9
	10E	1.2 ± 0.1
	15E	0.5 ± 0.1

TABLE 6 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE SOIL/BALLAST SAMPLES
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Grid Location[a]		Cs-137 (pCi/g)
260N	5W	3.1 ± 0.3
	5E	0.5 ± 0.2
	10E	0.4 ± 0.1
	15E	0.4 ± 0.1
270N	5W	2.3 ± 0.4
	5E	<0.1
	10E	1.9 ± 0.2
280N	5W	2.0 ± 0.3
	5E	0.5 ± 0.2
	10E	0.6 ± 0.1
290N	5W	0.7 ± 0.2
	5E	0.5 ± 0.1
	10E	0.4 ± 0.1
300N	5W	1.1 ± 0.2
	5E	0.3 ± 0.2
	10E	0.8 ± 0.1
310N	5W	<0.1
	5E	0.5 ± 0.2
	10E	0.7 ± 0.1
320N	5W	1.2 ± 0.2
	1E	0.3 ± 0.2
	5E	0.6 ± 0.2
330N	5W	0.2 ± 0.1
	1W	0.3 ± 0.1
	5E	1.3 ± 0.2
340N	5W	0.6 ± 0.2
	1E	0.7 ± 0.2
	5E	2.3 ± 0.2
350N	5W	0.8 ± 0.2
	1W	0.3 ± 0.2
	5E	3.2 ± 0.3
360N	5W	<0.1
	1E	0.7 ± 0.2
	5W	1.3 ± 0.2
370N	5W	<0.1
	1W	0.4 ± 0.1
	5E	0.3 ± 0.1
380N	5W	<0.1
	1E	0.7 ± 0.1
	5E	0.3 ± 0.1

[a]Refer to Figure 2.
[b]Errors are 2σ based only on counting statistics.

TABLE 7

CESIUM-137 CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL/BALLAST
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Location[a]	Grid Coordinates		Depth (cm)	Cs-137 (pCi/g)
1	99S	1E	0 - 15	1900 ± 40[b]
			55 - 60	47 ± 3
2	159S	0.5E	0 - 7	580 ± 10
			15 - 30	230 ± 10
			35 - 40	57 ± 3
3	160.5S	0.5W	0 - 15	100 ± 10
			15 - 30	160 ± 10
			35 - 40	110 ± 10
4	170S	1E	0 - 15	410 ± 10
			40 - 45	290 ± 10
5	188S	1E	0 - 15	610 ± 10
			50 - 55	190 ± 10
6	209.5S	0.5E	0 - 15	200 ± 10
			30 - 40	46 ± 2
7	290S	1.5E	0 - 15	220 ± 10
			30 - 35	74 ± 3
			35 - 40	24 ± 2
8	322S	0.5E	0 - 15	76 ± 3
			15 - 30	150 ± 10
			30 - 45	80 ± 3
9	345S	0.5E	0 - 15	110 ± 10
			15 - 30	110 ± 10
			30 - 45	66 ± 3
10	360.5S	0.5W	0 - 15	180 ± 10
			15 - 30	32 ± 2
			30 - 45	260 ± 10
11	394S	0.3W	0 - 15	2800 ± 50
			15 - 30	1500 ± 30
			30 - 45	790 ± 20
			60 - 75[c]	1.1 ± 0.2
			75 - 90[c]	0.2 ± 0.1
			90 - 105[c]	0.6 ± 0.1

TABLE 7 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL/BALLAST
CSX-EAST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Location	Grid Coordinate		Depth (cm)	Cs-137 (pCi/g)
12	399S	1E	0 - 15	570 ± 20
			15 - 30	320 ± 10
			30 - 40	180 ± 10
13	409S	1E	0 - 15	400 ± 10
			15 - 30	280 ± 10
			30 - 45	56 ± 3
14	433S	4E	0 - 15	1200 ± 30
			15 - 30	1900 ± 40
			65 - 75[c]	22 ± 1
15	441S	6E	0 - 15	510 ± 20
			45 - 50	200 ± 10
16	448S	6E	0 - 15	100 ± 10
			35 - 40	28 ± 3
17	457S	9E	0 - 15	67 ± 4
			35 - 40	6.6 ± 0.5
18	310S	5E	0 - 15	1.9 ± 0.2
			15 - 30	0.3 ± 0.1
			30 - 45	<0.1
			45 - 60[c]	<0.1
			60 - 75[c]	<0.1
			75 - 90[c]	<0.1
19	335S	1W	0 - 15	0.5 ± 0.1
			15 - 30	0.4 ± 0.1
			30 - 45	<0.1
			45 - 60[c]	<0.1
			60 - 75[c]	<0.1

[a]Refer to Figure 3.
[b]Errors are 2σ based only on counting statistics.
[c]Soil samples collected beneath ballast layer.

TABLE 8

CESIUM-137 CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL/BALLAST
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Location[a]	Grid Coordinates		Depth (cm)	Cs-137 (pCi/g)
1	300N	0.5W	0 - 15	1900 ± 60[b]
			15 - 30	380 ± 20
			45 - 60	<0.1
2	79.5N	0.8E	0 - 15	78 ± 4
			15 - 30	25 ± 1
			45 - 60	<0.1
3	94N	2E	0 - 15	500 ± 20
			15 - 30	18 ± 1
			45 - 60	<0.1
4	128N	3E	0 - 15	130 ± 10
			15 - 30	8.3 ± 1.3
			45 - 60	2.6 ± 0.3
5	151N	6E	0 - 15	57 ± 2
			15 - 30	110 ± 10
			45 - 60	2.2 ± 0.3
6	170.5N	7E	0 - 15	16000 ± 300
			15 - 30	6800 ± 700
			45 - 60	9.5 ± 0.5
7	143N	9E	0 - 15	7200 ± 100
			15 - 30	55 ± 3
			60 - 70	12 ± 1
8	202.5N	7E	0 - 15	660 ± 10
			15 - 30	1100 ± 20
			45 - 60	53 ± 3
			60 - 75	7.3 ± 0.4
9	209N	11E	0 - 15	97 ± 2
			15 - 30	5.3 ± 0.3
			45 - 55	2.3 ± 0.4
10	210.5N	8.5E	0 - 15	2700 ± 100
			15 - 30	1300 ± 100
			45 - 60	2.3 ± 0.5

TABLE 8 (Continued)

CESIUM-137 CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL/BALLAST
CSX-WEST PORTION OF THE CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Location[a]	Grid Coordinates		Depth (cm)	Cs-137 (pCi/g)
11	217.5N	7.5N	0 - 15	1.3 ± 0.2
			15 - 30	200 ± 10
			45 - 60	170 ± 10
12	220N	7.5E	0 - 15	360 ± 20
			15 - 30	300 ± 20
			60 - 75	0.7 ± 0.2
13	221N	0.5W	0 - 15	110 ± 10
			15 - 30	45 ± 3
			45 - 60	0.9 ± 0.1
14	239.5N	10E	0 - 15	54 ± 3
			15 - 30	63 ± 0.8
			45 - 60	<0.1
15	252.5N	3E	0 - 15	130 ± 10
			15 - 30	6.1 ± 0.5
			45 - 60	7.5 ± 0.6

[a]Refer to Figure 3.
[b]Errors are 2σ based only on counting statistics.

TABLE 9

RADIONUCLIDE CONCENTRATIONS IN DRAINAGE STREAM SAMPLES
CSX TRANSPORTATION GROUP SITE
OAK RIDGE, TENNESSEE

Type Sample	Location[a]	Concentration	
Water		gross alpha (pCi/l)	gross beta (pCi/l)
	1W	2.3 ± 0.9[b]	5.4 ± 1.1
	2W	2.6 ± 0.8	5.4 ± 1.1
Sediment		pCi/g Cs-137	
	1S	<0.1	
	2S	0.3 ± 0.1	

[a]Refer to Figure 4.
[b]Errors are 2σ based only on counting statistics.

Appendix C

SURVEY REPORT FOR THE CHARACTERIZATION OF RADIOLOGICAL CONTAMINATION OF THE CSX TRANSPORTATION GROUP RAILROAD TRACKS, OAK RIDGE, TENNESSEE

SURVEY REPORT FOR THE CHARACTERIZATION OF RADIOLOGICAL CONTAMINATION OF THE CSX TRANSPORTATION GROUP RAILROAD TRACKS OAK RIDGE, TENNESSEE

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Oak Ridge National Laboratory / Pollutant Assessment Group

September 4, 1990

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LIST OF ACRONYMS

Cs-137	cesium-137
DOE	Department of Energy
ESD	Environmental Sciences Division
HASRD	Health and Safety Research Division
HOG	highest outdoor gamma
LLRA	low level radiochemical analysis
MMES	Martin Marietta Energy Systems
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
PAG	Pollutant Assessment Group
PIC	pressurized ionization chamber
QA	quality assurance
QC	quality control
RASA	Radiological Survey Activities Group
RI/FS	Remedial Investigation/Feasibility Study
Sr-90	strontium-90

EXECUTIVE SUMMARY

This document serves as the preliminary radiological characterization for the CSX Transportation Group railroad tracks in Oak Ridge, Tennessee. This report was prepared by the Oak Ridge National Laboratory's Pollutant Assessment Group (ORNL/PAG), Grand Junction, Colorado, in conjunction with the Environmental Sciences Division (ESD) of ORNL. The results from this report are a combination of previous reports and surveys conducted March 6 to 13, 1990 and June 26 to 29, 1990 by the ORNL/PAG.

The objectives of this survey report are to assess and characterize the extent of radiological contamination in the CSX Transportation Group railroad tracks between Bear Creek Road and Elza Gate within Oak Ridge, Tennessee. The survey report will provide information necessary to prepare a Preliminary Assessment (PA) that will determine if a Remedial Investigation/Feasibility Study (RI/FS) is warranted.

The survey was conducted in a northeasterly direction away from the Oak Ridge Y-12 Plant. Several residential neighborhoods were located along the CSX railroad tracks. The survey included all track ballast and extended a minimum of five m (16 ft) beyond each side of track. The survey procedures included: establishing a 100 m grid along the track centerline; conducting a complete walkover gamma radiation scan; delineating deposits; sampling the soil/ballast material; conducting a complete gamma spectral analysis; and analyzing for total uranium, gross alpha, gross beta, and strontium-90 in ballast material.

As an addendum to the CSX work plan, three vicinity properties within close proximity to the railroad contamination were scanned for elevated gamma exposure rates. No elevated readings were encountered during these surveys.

Ten regions of elevated gamma exposure rates above the general background of 5 to 9 μR/h were located along the CSX railroad tracks. These regions ranged from 10 to 850 μR/h at the surface and 7 to 75 μR/h at one meter above the surface. Three additional areas of elevated gamma exposure rates were located and attributed to gamma emanation fields associated with the Quadrex Corp. Plant and to radiation inherent to the natural material within the ballast.

The preliminary assessment demonstrates that cesium-137 is the primary contaminant of concern. The Department of Energy (DOE) has not established a specific guideline for Cs-137 contamination in soils for unrestricted areas; however, the Nuclear Regulatory Commission (NRC) has used a guidance level of 17 pCi/g for sites being released from licensing controls. The estimated volume of material exceeding this guideline is 47 m^3.

Due to the lack of chemical evaluations and possibility of contaminant migration, further investigations in the form of an Remedial Investigation and Feasibility Study (RI/FS) is recommended.

1.0 INTRODUCTION

A radiological and chemical surface characterization survey of the Oak Ridge Y-12 Plant was conducted in early 1986 by the Radiological Survey Activities Group (RASA) of the Health and Safety Research Division (HASRD) of Oak Ridge National Laboratory (ORNL). During this survey, cesium-137 (Cs-137) contamination was identified in several locations at the east end of the Y-12 Plant. Localized areas of contamination were found along both sets of the CSX Transportation Group railroad tracks west of Scarboro Road near the eastern perimeter of the Y-12 Plant. At the request of Y-12 management, a preliminary survey for radionuclide contamination was also conducted by RASA personnel along the CSX railroad spur east of Scarboro Road [Plate 1, (Fig. 1)]. Additional areas of contamination were located along this spur which is easily accessible to the general public (Foley 1986).

To further delineate the extent, levels, and type of radiological contamination in the areas east and west of Scarboro Road, a follow-up study was commissioned by the Department of Energy (DOE) and was conducted by the Radiological Site Assessment Group of Oak Ridge Associated Universities (ORAU) in November 1986 with a report issued to the Department of Energy (DOE) in February, 1987 (ORAU 1987). The ORAU survey further delineated the areas and concentrations of Cs-137 contamination in the railroad ballast east and west of Scarboro Road. Because the extent of the Cs-137 contamination was uncertain, a complete radiological characterization of the CSX Transportation Group railroad tracks in Oak Ridge was needed. Therefore, a work plan was developed (Appendix A) in March, 1989, tasking the ORNL/Pollutant Assessment Group (PAG) to survey the 11.2 km (7 mi.) of track between Bear Creek Road and Elza Gate [Plate 1, (Figs. 1-5)]. Between March 6 to 13, 1990 and June 26 to 29, 1990, a preliminary radiological characterization of the CSX Railroad tracks was conducted by ORNL/PAG. The procedures and findings of that survey are presented in this report.

2.0 SITE DESCRIPTION

The survey began approximately 30 m (98 ft) north of the intersection of Bear Creek Road and Scarboro Road [Plate 1, (Fig. 1)]. The survey proceeded along the CSX tracks in a northeasterly direction away from the Y-12 Plant and terminated at Elza Gate near the eastern edge of Oak Ridge as outlined in the work plan (Appendix A). The tracks follow Scarboro, Lafayette, Fairbanks, and Warehouse Roads, respectively. Residential properties are located along the CSX property lines at several locations. Several homes are located 15 m (49 ft) to the south of placards 1900 through 2500 [Plate 1, (Figs. 2 and 3)]. Residential neighborhoods are also located to the south of Fairbanks and portions of Warehouse Roads. Area businesses are located along the sidings within the switch yard area on Warehouse Road. All other areas within this survey are predominantly undisturbed land. Public access to the tracks within these areas is unrestricted.

The survey included all track ballast and extended a minimum of five m (16 ft) on each side of the tracks. All railroad sidings were surveyed approximately 100 m (328 ft) beyond the intersection with the main tracks. The main switch yard contained multiple sidings that were labeled alphabetically and surveyed as described within the procedure survey section (see Section 3). Areas within the CSX railroad boundary with unusual characteristics (i.e., piles of dirt, old rail beds, and dissimilar ballast) were also surveyed. All data collected from this and prior surveys will determine whether or not there is compliance with federal and/or state regulations and will be used to assess the magnitude and immediacy of risk from the contamination. Recommendations for further actions will be made based on these findings and included in the final report to DOE.

3.0 PROCEDURES

1. For survey and sampling reference, a 100-m (328-ft) grid was established along the centerline of each section of track. Every 100-m section of track was labeled with a circular aluminum placard. The grid origin and corresponding 100-m increments are shown on Plate 1 (Fig. 1 through 5). All survey activities were recorded relative to these grid markers.

2. A complete walkover gamma screening was performed using methods outlined in the **ORNL/PAG Procedures Manual** (Little et al. 1990). Measurements were taken with

Victoreen Thyac III portable gamma scintillometers. Areas with elevated gamma measurements above the general background range of 5 to 9 μR/h were marked for further investigation.

3. Exposure rates were measured at the surface and at one meter above the surface. The exposure rates were then entered on the corresponding gamma screening sheets (Appendix B). The conversions of the exposure rates from kcpm to μR/h was determined by on-site cross calibration of the portable rate meter with a pressurized ionization chamber (PIC). This information was utilized to construct a correlation curve as shown in Figure 1.

The conversion formula is:

$$y = mx + b$$

Where: y = exposure rate (μR/h),
m = slope of line (μR/h per kcpm),
x = scintillometer measurement in (kcpm),
b = intercept (μR/h),

or:

$$y = 1.06x + 2.85.$$

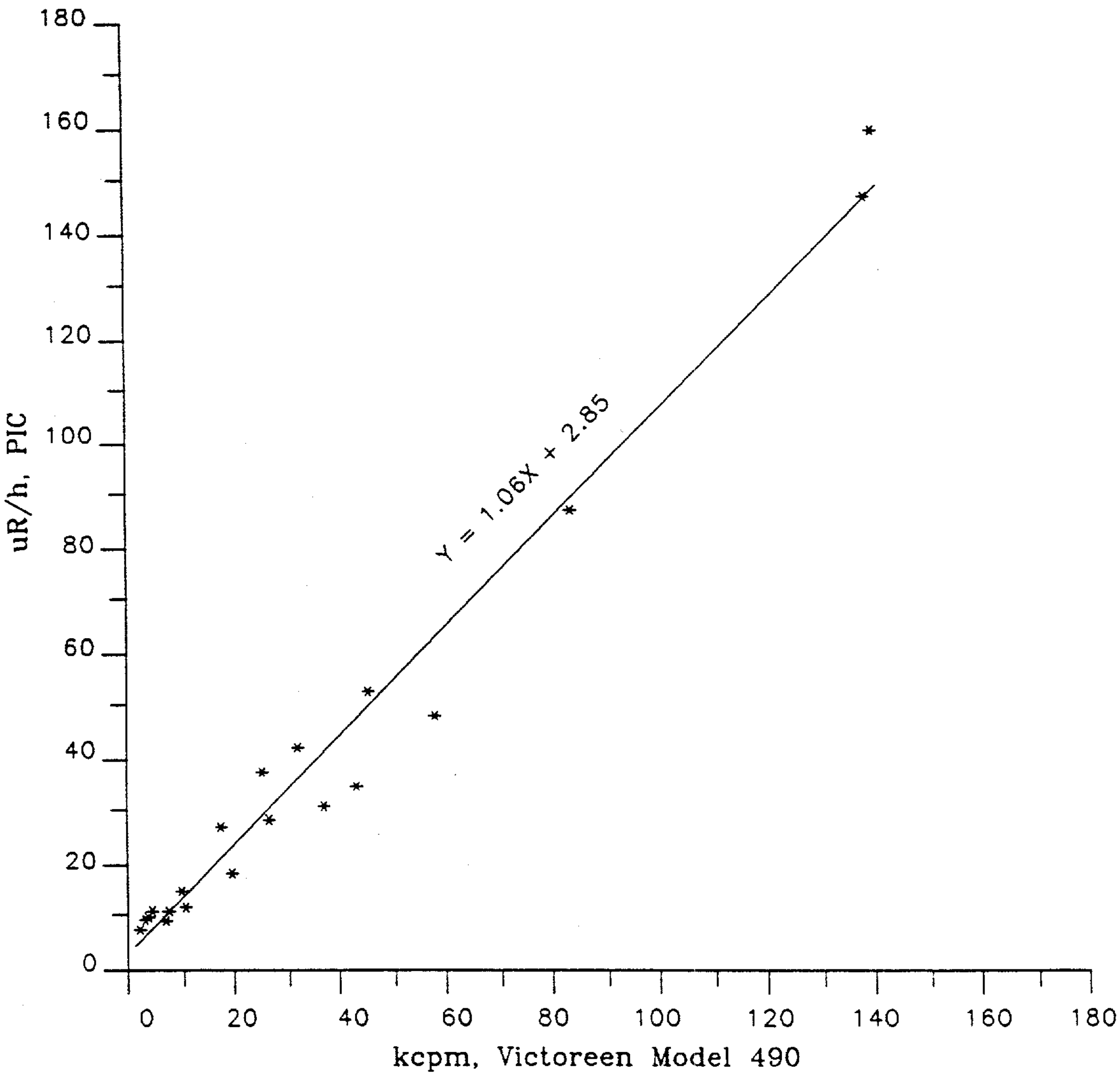

Fig. 1. Gamma correlation curve

4. After completion of the walkover gamma scan, areas with elevated gamma exposure rates above the general background were delineated and sampled accordingly. Samples were taken from contaminated regions that were representative of the surrounding deposits with similar exposure rate ranges. Some deposits were not sampled since the size or location of the contamination made sampling infeasible (i.e., railroad tie involvement and/or sampling areas $< 2\ m^2$ in size). Several larger regions were sampled at the highest outdoor gamma (HOG) and the next highest gamma within 2 m of the HOG. These samples provide a conservative estimate of the mean concentration of the radioactivity associated with the deposit. Soil sample depth was dependent on the gamma readings. A gamma scintillometer measurement was taken on the surface and recorded. Another gamma reading was taken at each subsequent depth after a sample was taken. If gamma measurements increased by more than 20% (a maximum of 20% increase is due to the effect of geometry in the hole on the probe), sampling at subsequent depths was continued until readings stabilized or decreased (Little et al. 1990). Additional soil samples were collected to meet QA/QC procedure requirements. In addition, chain-of-custody forms and custody seals were used during sample collection and transport.

5. The following radiological analyses were performed on the soil/ballast samples by the Low-Level Radiochemical Analysis Group (LLRA) of the Analytical Chemistry Division of ORNL: gamma spectral analysis, gross alpha, gross beta, total uranium, and strontium-90 (Tables 2 and 3). Samples were dried and ground before analyzing. The analyses performed by the LLRA were in accordance with the procedures provided in the Martin Marietta Energy Systems Environmental Analysis Manual (MMES 1988). It should be noted that chemical analyses were not performed during this survey.

6. As an addendum to the objectives of the original work plan, three vicinity properties adjoining CSX property near the switching yard were surveyed. These homesite surveys were prompted by the preliminary results from the track survey. At each homesite, a property drawing including all structures, estimated property lines, streets, concrete, and land marks was prepared. The property was then surveyed as described within Section 3 of the Procedures. All survey activities are outlined in the Pollutant Assessment Group Procedures Manual (Little et al. 1990).

4.0 RESULTS

4.1 Walkover surface gamma screening

The walkover gamma survey of the railroad tracks identified the regional gamma background range to be 5 to 9 μR/h at the ballast surface and 5.5 to 8 μR/h at one meter above the surface. Ten regions with elevated surface gamma readings ranging from 10 to 850 μR/h were located along the tracks and labeled A through J [Plate 1, (Figs. 1 and 4a)]. The 850 μR/h readings were determined to be isolated areas within these deposits. Regions A through I were located within the CSX switch yard along a railroad siding designated as Track B [Plate 1, (Fig. 4a)]. Region J [Plate 1, (Fig. 1)] was located near the beginning of the survey at placard 60,0. The deposits with elevated readings above background ranged from 1 m^2 to 58 m^2 in size. The surface and one meter gamma ranges for all deposits are listed in Table 1. Three additional areas with elevated gamma readings were located within the CSX property boundaries. Area 1 was located behind Quadrex Corporation's plant (a nuclear decontamination and waste processing plant located between placards 2000 and 2300 on the main track). The elevated readings from Area 1 were determined to be a gamma emanation field from radioactive waste stored on the Quadrex site [Plate 1, (Fig. 2)]. Area 2, a small igneous rock approximately 10 cm in diameter, was located at placard 3480,0 with a slightly elevated gamma exposure rate reading of 15 μR/h [Plate 1, (Fig. 3)]. This rock was not removed from the property. Area 3, the ballast between placards 4664 and 4750, had slightly elevated gamma readings of 9 to 13 μR/h. The elevated readings at Area 3 were determined to be inherent to the natural material within the fine crystallin dolomite [Plate 1, (Fig. 4)]. The elevated readings within these three areas were not a result of contaminated ballast.

Table 1. Compiled data from contaminated regions

REGION	TRACK DESIGNATION	LOCATION from 0,0 (meters)	GAMMA RATE RANGE uR/h		SIZE (m^2)	SOIL SAMPLE NUMBERS
			Surface	1 Meter		
A	B	72–74	13–215	7–45	2	N/A
B	B	80–81	10–18	7.0	2	N/A
C	B	82–85	10–215	7–46	5	N/A
D	B	90–91	10–82	7–24	3	3305
E	B	100–105	10–850	7–56	17	3304 3308 3309 3310 3311
F	B	109–111	10–108	7–29	3	N/A
G	B	115–124	10–850	7–75	58	3312 3313 3314
H	B	248–250	10–215	7–24	3	N/A
I	B	248–256	10–15	7–8	10	3306 3307
J	MAIN	60	13–26	7–7.5	<1	N/A

4.2 Radiological Analysis of Soil/Ballast Samples

Guided by the results of the walkover survey, sixteen, 600- to 800-g soil/ballast samples were collected from within the CSX property boundary. Two preliminary soil samples, numbers 3304 and 3305, were collected in March from the switch yard solely for screening purposes to determine the type of contaminant and future sampling rationale. These samples were not dried before analysis (as noted in Table 2) and results should be used only as a rough estimate of the actual dry weight activity. Five samples were collected from Region E, 3 from Region G, 2 from Region I, and 1 from Region D [Plate 1, (Fig. 4a)] and ranged in activity from 1.05 to 21,870 pCi/g of Cs-137. Four soil samples ranging from 0.49 to 1.3 pCi/g of Cs-137 were collected behind the Quadrex site to determine if the elevated gamma exposures were spillover contamination or a gamma emanation field produced by the radioactive waste storage (Table 2)[Plate 1, (Fig. 2)]. Because of the lack of elevated readings from the soil samples taken near Quadrex, contamination within the soil matrix is not probable. Therefore, the theory of an emanation field is founded. Soil samples 3306 through 3315 were analyzed for total uranium and strontium-90. These results were determined to be within the regional background range. All soil sample data are provided in Tables 2 and 3.

4.3 Vicinity Property Gamma Screening

Because the Cs-137 contamination located within the warehouse area of Oak Ridge is within close proximity to a residential area, DOE requested that three homesites with property lines adjoining CSX property be surveyed. No elevated readings above the regional background of 5 to 9 μR/h were located on any of the property sites. The results from these investigations are located in Appendix C.

Table 2. Results of gamma spectral analysis, concentrations are reported on a dry weight basis unless otherwise noted

SAMPLE IDENTIFICATION	LOCATION	DEPTH (cm)	Cs−137 CONCENTRATION pCi/g
3300[d]	QUADREX	0 − 2.5	1.3 ± 0.1
3301[d]	QUADREX	2.5 − 15	0.88 ± 0.05
3302[d]	QUADREX	0 − 2.5	1.1 ± 0.07
3303[d]	QUADREX	2.5 − 15	0.49 ± 0.05
3304[d]	E	0 − 15	>34000[b]
3305[d]	D	0 − 15	592
3306	I	0 − 15	29.7 ± 2.7
3307	I	0 − 15	37.8 ± 2.7
3308	E	0 − 15	21,870 ± 270
3309	E	15 − 30	9,720 ± 270
3310[a]	E	15 − 30	4,050 ± 270
3311	E	30 − 45	5,670 ± 270
3312	G	0 − 15	459 ± 27
3313	G	0 − 15	2,178 ± 27
3314	G	15 − 30	1,728 ± 27
3315	RANDOM	0 − 15	1.05 ± 0.16[c]

[a] Split sample of 3309.

[b] Exceeded the capacity of the counter (7.06 g = 95,000 pCi/g ± 250).

[c] Background concentrations of Cs−137 in soils in Oak Ridge, Tn. range from 0.1 to 2.0 pCi/g.

[d] Samples taken for screening purposes only, concentrations are in pCi/g wet weight.

Table 3. Results of radiological analysis, concentrations are reported on a dry weight basis unless otherwise noted

SAMPLE IDENTIFICATION	TOTAL URANIUM pCi/g	STRONTIUM-90 pCi/g	GROSS ALPHA pCi/g	GROSS BETA pCi/g
3306	0.945 ± .08	0.378 ± .54	5.67 ± 4.05	25.4 ± 7.56
3307	0.972 ± .16	0.027 ± .43	5.40 ± 4.05	37.8 ± 8.10
3308	0.756 ± .24	0.240 ± 1.08	11.0 ± 9.18	19,710 ± 270
3309	0.702 ± .14	0.920 ± .62	4.32 ± 3.78	11,340 ± 270
3310	0.540 ± .22	1.760 ± 1.24	1.62 ± 3.78	8,640 ± 270
3311	0.540 ± .22	0.760 ± 0.84	5.40 ± 4.86	8,100 ± 270
3312	0.648 ± .14	0.110 ± .54	2.70 ± 2.97	324 ± 27
3313	1.026 ± .22	<.35	6.48 ± 4.32	2,160 ± 54
3314	0.378 ± .11	0.46 ± .51	2.97 ± 3.24	1,944 ± 54
3315	0.549 ± .16	0.590 ± .62	8.64 ± 5.13	10.8 ± 6.48

5.0 CONCLUSIONS

A survey of the CSX Transportation Group railroad right-of-way, from 30 meters beyond the intersection of Bear Creek Road and Scarboro Road to Elza Gate in Oak Ridge, Tennessee, was performed by the Pollutant Assessment Group of Oak Ridge National Laboratory between March 6-13, 1990 and June 26-29, 1990. The survey revealed elevated gamma exposure rates above the regional background of 5 to 9 μR/h. The maximum direct gamma exposure rate at 1 m above the surface was determined to be 75 μR/h. Soil sample results indicated the presence of Cs-137 ranging in levels of 30 pCi/g to 21,870 pCi/g within the contaminated regions. Background Cs-137 levels from this and previous surveys appear to be 0.1 to 2 pCi/g (ORAU 1987). The contamination was primarily within the upper 45 cm of ballast or soil; with few exceptions, it was limited to the area within 2 m of the track centerline. Two regions of contamination, G and I, were predominantly within the low-lying area located between railroad sidings "B" and "C".

The Department of Energy (DOE) has not established a specific guideline for Cs-137 contamination in soils for unrestricted areas; however, the Nuclear Regulatory Commission (NRC) has used a guidance level of 17 pCi/g for sites being released from licensing controls (ORAU 1987). Based on an area of contamination of 104 m^2 and an average depth of 45 cm, the estimated volume of soil exceeding the NRC's 17 pCi/g guideline concentration for Cs-137 is 47 m^3.

No elevated gamma readings above the general background range were encountered during the vicinity property survey. However, there is a possibility of contaminant migration within the drainage pathways. Moreover, because of the difficulty in sampling the ballast material and the lack of chemical evaluations, the full extent of the contamination could not be delineated. Therefore, an RI/FS is recommended to assure appropriate remedial action and complete waste characterization.

6.0 REFERENCES

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APPENDIX A

WORK PLAN FOR CSX SURVEY

WORK PLAN FOR THE CHARACTERIZATION AND ASSESSMENT OF RADIOLOGICAL CONTAMINATION OF THE CSX TRANSPORTATION GROUP RAILROAD TRACKS

Project Manager S. B. Garland II
Environmental Sciences Division

March 1989

Work Plan for the Characterization and Assessment of Radiological Contamination of the CSX Transportation Group Railroad Tracks

1.0 PURPOSE

The purpose of this work plan is to outline a program: (1) to locate and characterize radiological contamination along the CSX Transportation Group (CSX) railroad tracks in Oak Ridge; (2) to provide for the QA for the characterization study; and (3) to assess the risk to the public, railroad workers, and environment from the contamination.

The objectives of the characterization phase of the project are to:

- identify the presence of radiological contaminants in the ballast and soils below the ballast of the CSX Transportation Group railroad tracks northeast of the Y-12 Plant;
- delineate the horizontal and vertical extent of the radiological contamination along the tracks;
- characterize the types and levels of the contaminants:
- provide a data base to be used in the determination of compliance with state and federal regulations and in the assessment of risk associated with the contamination.

The objectives of the assessment phase of the project are to:

- review applicable or relevant and appropriate regulations to determine compliance with established limits or guidelines for radiological contamination;
- prepare a preliminary report for the Department of Energy (DOE) assessing the risk to the public, including railroad workers, based on existing data from previous surveys of the contamination;
- prepare a final assessment of the risk to the public from the contamination and recommend future actions based on data from the characterization study outlined in this work plan and data from previous studies.

Results of the characterization study and risk assessment will be included in a final report to the DOE presenting recommendations for future actions. An organizational chart for the project is given in Attachment 1.

2.0 BACKGROUND

A radiological and chemical surface characterization survey of the Y-12 Plant Site was conducted in early 1986 by the Radiological Survey Activities Group (RASA) in the Health and Safety Research Division (HASRD) of Oak Ridge National Laboratory (ORNL). During this survey, Cs-137 contamination was identified in several locations at the east end of the plant. Localized areas of contamination were found along both sets of the CSX Transportation Group railroad tracks west of Scarboro Road near the eastern perimeter of the Y-12 Plant. At the request of Y-12 management, a preliminary survey for radionuclide contamination was also conducted by RASA personnel along the CSX railroad spur east of Scarboro Road across from the Y-12 Plant. Additional areas of contamination were located along this spur which is easily accessible to the public (Foley, 1986). To further delineate the extent, levels and types of radiological contamination in the areas east and west of Scarboro Road, a follow-up study was commissioned by the Department of Energy and conducted by the Radiological Site Assessment Group of Oak Ridge Associated Universities (ORAU) in November 1986 with a report issued to DOE in February 1987 (ORAU, 1987). The ORAU survey further delineated the areas and concentrations of Cs-137 contamination in the railroad ballast east and west of Scarboro Road and discounted the presence of other gamma-emitting radionuclides above background ranges. With only a few exceptions, elevated readings were within 1 m of the track centerline and were confined to the ballast above the soil.

Although the original source of the Cs-137 contamination is unknown and may never be known, it has been suggested that the contamination occurred during waste transfer operations during the period (1955-1963) when Oak Ridge National Laboratory was designated by the Atomic Energy Commission as a regional waste disposal site for radioactive wastes. During that period, most shipments of waste were transported by truck directly to ORNL, but some also came in by rail to Y-12 for eventual transfer by truck to the Solid Waste Storage Areas (SWSAs) at ORNL. It was suggested that contamination of the track area occurred during the off-loading of radioactive wastes from the railroad cars. This theory, however, is not supported by results from aerial radiological surveys of the Oak Ridge reservation conducted by EG&G Energy Measurements, Inc. in 1973, 1974 (Burson, 1976) and 1980 (Boyns, 1984). None of these surveys showed the presence of Cs-137 contamination in the vicinity of the CSX tracks at Y-12 suggesting that the contamination occurred sometime after the last aerial survey in 1980 and after ORNL served as a regional disposal site.

Since there is a great deal of uncertainty concerning the source and extent of the Cs-137 contamination, a more complete characterization of the contamination is required in order to determine the scope of needed remediation measures . For instance, a determination of the possible presence of radioactive contamination along the tracks beyond the immediate vicinity of the Y-12 Plant is needed. This work plan presents a survey and sampling plan designed to accomplish this. As mentioned above, data from the characterization study will be used in conjunction with data from the previous ORAU and ORNL surveys to determine whether or not there is compliance with federal and/or state regulations and to assess the magnitude and immediacy of risk from the contamination. Recommendations for future actions will be made based on these findings and included in the final report to DOE.

3.0 CHARACTERIZATION STUDY

3.1 Rationale

The strategy proposed for the characterization study for this project consists of two phases. The two-phased approach allows for modifications to be made to the second phase dependent upon the results from the first phase. Phase I will consist of a walk-over gamma exposure scan conducted by staff of the Pollutant Assessment Group in the Health and Safety Research Division (HASRD) of ORNL. Permission will be requested and received from CSX before beginning any survey work along the railroad's right-of-way. The Division Engineer for CSX will be notified a minimum of seventy-two hours before the commencement of any survey work.

The survey will originate at the track juncture approximately 30 meters north of the intersection of Bear Creek Road and Scarboro Road and proceed along the CSX tracks in a northeasterly direction away from the Y-12 Plant terminating at Elza Gate near the eastern edge of the town of Oak Ridge. Areas showing higher than background gamma readings will be flagged for possible later sampling. The contamination in the immediate vicinity of the Y-12 Plant has already been well characterized in the previously mentioned ORNL and ORAU reports and will not be re-surveyed.

If areas of significant contamination (greater than two times the normal background levels) are found during the Phase I walk-over gamma survey, a Phase II sampling program will be conducted to identify the radionuclides and to determine their concentrations. The Phase II program will consist of sampling surface and subsurface ballast at several of the identified hot spots as well as at a number of random locations. The number of samples collected will depend on the extent of contamination found.

3.2 Field and Laboratory Documentation

Field documentation for Phases I and II of the characterization study will be in accordance with the *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600 (RASA Procedures Manual) (Myrick et al., 1987), the *Radiological Survey Activities Uranium Mill Tailings Remedial Action Project (UMTRA) Procedures Manual*, ORNL/TM-9902 (UMTRA Procedures Manual) (Little et al., 1986), and the *Environmental Surveillance Procedures Quality Control Program* (QC Manual) (Kimbrough et al., 1988). To provide a permanent record of field operations, all field entries will be made into a controlled and protected Field Data Log Book. In the field log book will be recorded all data relevant to the survey and sampling proceedings including, but not limited to, personnel present, equipment used, unusual occurrences, significant problems or delays, and changes made in field equipment, procedures or personnel. Entries in the field log book will be the responsibility of one of the field crew members and will be checked and initialed by him at the end of the day's activities. Daily entries will be reviewed and signed by the survey team leader. When not in use, the log book will be kept by the survey team leader or his appointee in a secure area (locked and out of sight). Laboratory entries will be recorded in the Sample Preparation Log Book and the Sample Data Log Book maintained by the Measurement, Applications and Development Group (see Sect. 15, Myrick et al., 1987) or the Pollutant Assessment Group of HASRD.

Standard chain-of-custody forms (see Attachment 2) will be maintained for all samples collected.

3.3 Phase I - Gamma Exposure Rate Survey

Comprehensive descriptions of the survey methods, instrumentation and instrument calibration procedures to be used are available in the RASA Procedures Manual (Myrick et al., 1987) and the UMTRA Prodedures Manual (Little et al., 1986).

3.3.1 Survey Location

As discussed above, the walk-over gamma survey will begin along the railbed approximately 30 meters north of the intersection of Bear Creek Road and Scarboro Road at the split of the main railroad tracks into the two railroad spurs that terminate either east or west of Scarboro Road. This location will be designated Site 0 and used as the primary reference point for survey activities. Secondary reference points will be established and identified by their distance from point 0. The distance between the primary and secondary reference points will be measured by rolling a measuring wheel along one of the rails. Secondary reference points may be designated and marked after an arbitrarily established distance (e.g. 100 m) has been traversed or at an easily identified structure along the track. The survey will proceed along the main track in a northeasterly direction and terminate just before the tracks cross Oak Ridge Turnpike near Elza Gate at the eastern edge of the city of Oak Ridge. In addition to the main railbed, all accessible sidings, railroad spurs and identifiable abandoned railbeds between Site 0 and the terminus will be surveyed.

3.3.2 Gamma Survey Methodology

Exposure rate measurements will be made using a portable gamma scintillation meter. The instrument used will be a Victoreen portable ratemeter, Model 490 Thyac III with a 1¼ X 1½ in sodium iodide (thallium) probe. Since scintillation meter readings are in counts per minute (cpm), these readings will be converted to an exposure rate in microroentgens per hour (μR/h) by onsite cross calibration of a number of scintillation meter readings with a corresponding number of Pressurized Ionization Chamber (PIC) measurements. Laboratory and field calibration procedures and calibration documentation for the PIC and the gamma scintillation meter are given in sections 16.3, 20.9 and 20.10 of the RASA Procedures Manual and sections 9 and 11 of the UMTRA Procedures Manual. If radiation fields exceeding the range of the scintillation meter are encountered, direct exposure rate measurements will be made with the ionization survey meter.

Background exposure rates will be established using procedures outlined in the RASA Procedures Manual (Myrick et al., 1987). Scans of the railroad bed will be made while holding the detector near the railbed surface and walking back and forth across the railroad tracks. Scans will extend a minimum of one meter beyond the edge of the tracks. For each 50 meter length of track surveyed, an average observed detector response will be recorded on a standardized data form (see Attachment 3) in the Field Data Log Book. If areas of elevated activity (greater than twice normal background) are encountered, the location will be recorded (i.e., distance from the primary or a secondary reference point and distance and direction from the centerline of the track), the site flagged, and an exposure rate taken and recorded at the railbed surface and at one meter above the surface. All elevated readings will be entered on the standardized data forms.

3.4 Phase II - Sample Collection and Analysis

If areas of elevated radiation levels are located during the Phase I gamma survey, Phase II sampling will be conducted. Sample collection will be undertaken in accordance with procedures outlined in more detail in the RASA Procedures Manual (Myrick, et al., 1987) and in the QC Manual (Kimbrough et al., 1988). No samples will be collected in the event that areas of elevated activity are not located.

3.4.1 Sample Locations

The exact locations and number of samples to be collected will be determined after the results of the Phase I gamma survey are known. If areas of radionuclide contamination are identified during the Phase I survey, a minimum of 20 biased or selective samples from sites of abnormally high radiation levels (i.e., greater than two times the normal background level) will be taken unless the small number of identified contaminated areas precludes this. In addition to the biased samples, approximately 10 to 20% of the total number of samples collected will be random samples. Once sample locations have been chosen based on the Phase I results, all sampling locations will be defined by their distance from primary or secondary reference points and the bearing and distance from the centerline of the track.

3.4.2 Sample Collection Methodology

Samples will be taken at different depths within the ballast using trowels, scoops or other appropriate equipment. An effort will be made to remove the largest pieces of rock from the ballast sample and concentrate on retaining the fine material. Each sample will consist of approximately 0.8 kg of material packaged in plastic bags for transfer to ORNL for processing. Bags will be labeled and sealed following chain-of-custody procedures. Each sample will be given an unique alphanumeric identification following guidelines given in Section 14 of the Procedures Manual (Myrick, et al., 1987). The format for the sample identification alphanumeric (SIA) will be established by the survey team leader (i.e., E. K. Roemer) and entered into the Field Data Log Book. As each sample is collected, the corresponding SIA will be entered into the Field Data Log Book and on chain-of-custody forms along with the site location, time and date of collection, and initials of sample collectors.

3.4.3 Sample Analysis

The following radiological analyses will be performed on the ballast samples in the laboratory: gamma spectral analysis, gross alpha, gross beta, total uranium and Sr-89/90. The Measurement, Applications, and Development Group or the Pollutant Assessment Group of HASRD will prepare the collected samples and perform the gamma spectral analysis using procedures documented in Sect. 15 of the RASA Procedures Manual (Myrick et al., 1987). Upon completion of the gamma spectral analysis, the samples will be sent (along with their appropriate chain-of-custody documentation) to the Low-level Radiochemical Analysis Group (LLRA) of the Analytical Chemistry Division of ORNL for determination of gross alpha, gross beta, total uranium, and Sr-89/90. Analyses performed by staff of LLRA will be in accordance with those provided in the *Martin Marietta Energy Systems Environmental Analysis Manual* (MMES 1988).

3.4.4 Chain-of-Custody Procedures

Chain-of-custody procedures, including the maintaining of chain-of-custody forms for all samples, will be followed throughout the sampling and analysis phase. These procedures, designed to ensure the integrity of samples from the time of their collection until their final disposition, are described in detail in the QC Manual (Kimbrough et al., 1988).

3.5 Personnel Safety and Protection

Before entry upon CSX property, the survey team will notify the Division Engineer for CSX and the Knoxville office of CSX at least seventy-two hours prior to entry and will abide by all instructions from CSX concerning the safety of the railroad or of the survey team entering CSX property. During the survey and sampling work, one member of the field survey crew will be designated as a look-out for the survey team. He will be posted along the tracks within voice distance of the field survey/sampling crew and will have the sole responsibility of monitoring and alerting, using a whistle or air horn, the field crew to any train movement along the tracks. If such movement represents a hazard to the field crew, survey/sampling activities will cease until the hazard has passed. The field crew will carry a two-way radio or cellular phone for contacting the ORNL shift supervisor in case of an emergency.

Procedures for personnel exposure monitoring and protection are outlined in Section 17.3 of the Procedures Manual (Myrick, 1987) and in the QC Manual (Kimbrough, 1988) and will be followed during the survey and sampling phases of the characterizaion study. As a minimum, field personnel will be required to wear steel-capped safety shoes and safety glasses. When collecting and handling samples, personnel will wear gloves to minimize the chance of personnel contamination and cross-contamination of samples. If there is a high probability of contaminating clothing during the field survey, field personnel will wear company-issued protective clothing or disposable anticontamination apparel. In addition to the measures taken above to ensure safety, a ESD Project Safety Summary will be completed and submitted for approval. (see Attachment 4 for ESD Project Safety Summary)

3.6 Waste Management

The survey and sampling phases of the characterization study are expected to generate little, if any, waste. In the event that reusable protective clothing (eg. coveralls, rubber boots) is worn during the survey work and has become contaminated, that clothing will be placed in a transparent plastic bag. The bag will be sealed with tape, checked by a health physicist (HP), tagged, and dropped off at the ORNL laundry for cleaning. Disposable protective clothing (eg. Tyvek coveralls, rubber gloves, shoe covers) and miscellaneous compactible trash that may have become contaminated, will be collected into the transparent, yellow plastic bags designated for low-level contaminated waste, checked by a HP, tagged, and properly disposed of as low-level compactible radioactive waste. Any non-contaminated trash that might be generated during the survey operations will be bagged separately and disposed of in the proper receptacles in the plant area.

3.7 Quality Assurance

Because of the limited scope of this project, a full-fledged NQA-1 plan will not be required. However, certain measures mentioned previously in the text of this document will be taken to ensure QA for this project. These measures include:

- a project organizational plan (see Attachment 1);
- maintenance of a protected Field Data Log Book for recording field entries (see Section 3.2 above);
- the use of documented calibration procedures for field survey equipment (see Section 3.3.2 above);
- the use of chain-of-custody procedures for all samples collected (see Sections 3.4.2 and 3.4.4 above);
- the use of documented procedures for sample analyses (see Section 3.4.3 above).

4.0 ASSESSMENT OF RISK

A report presenting a review of applicable or appropriate and relevant regulations and a preliminary assessment of radiation doses to the public resulting from the Cs-137 contamination will be prepared for DOE. This initial assessment will be completed before the characterization study is initiated and will be based primarily on data available in the ORAU survey (ORAU, 1987). After completion of the characterization study, a final assessment will be prepared incorporating the new data from the characterization study as well as data from existing reports. In order to refine the dose analysis to railroad workers, information concerning possible exposure times to railroad workers from routine as well as maintenance activities along the tracks will be sought from CSX and become part of a final assessment. The risk assessment and recommendations for accomplishing any needed remediation based on regulatory guidelines will be included in a final report to DOE.

5.0 APPROVALS

Project Manager _______________ Date 31 Mar 89

QA Coordinator L.E. Roberson Date 3/28/89

ESD Safety Officer _______________ Date 3/29/89

Supervisor of
Waste Operations J.C. Van Cleave Date 3/23/89

6.0 REFERENCES

Boyns, P. K., 1984. An Aerial Radiological Survey of the Oak Ridge Reservation, Oak Ridge, Tennessee (June 1980). Report No. EGG-10282-1001. Las Vegas, NV: EG&G/EM.

Burson, Z. G., 1976. Aerial Radiological Survey of ERDA'S Oak Ridge Facilities and Vicinity (Survey Period: 1973-1974). Report No. EGG-1183-1682. Las Vegas, NV: EG&G/EM.

Foley, R. D., 1986. "Cesium-137 Contamination," memorandum to G. E. Kamp (June 26).

Kimbrough, C. W., L. W. Long, and L. W. McMahon, 1988. Environmental Surveillance Procedures Quality Control Program, Martin Marietta Energy Systems, Inc., ESH/Sub/87-21706/1.

Little, C. A., B. A. Berven, T. E. Carter, M. L. Espegren, F. R. O'Donnell, S. J. Ramos, C. D. Retolaza, A. S. Rood, F. A. Santos, D. A. Witt, K. M. Woynowskie, 1986. Radiological Survey Activities - Uranium Mill Tailings Remedial Action Project (UMTRA) Procedures Manual, ORNL/TM-9902, Oak Ridge National Laboratory.

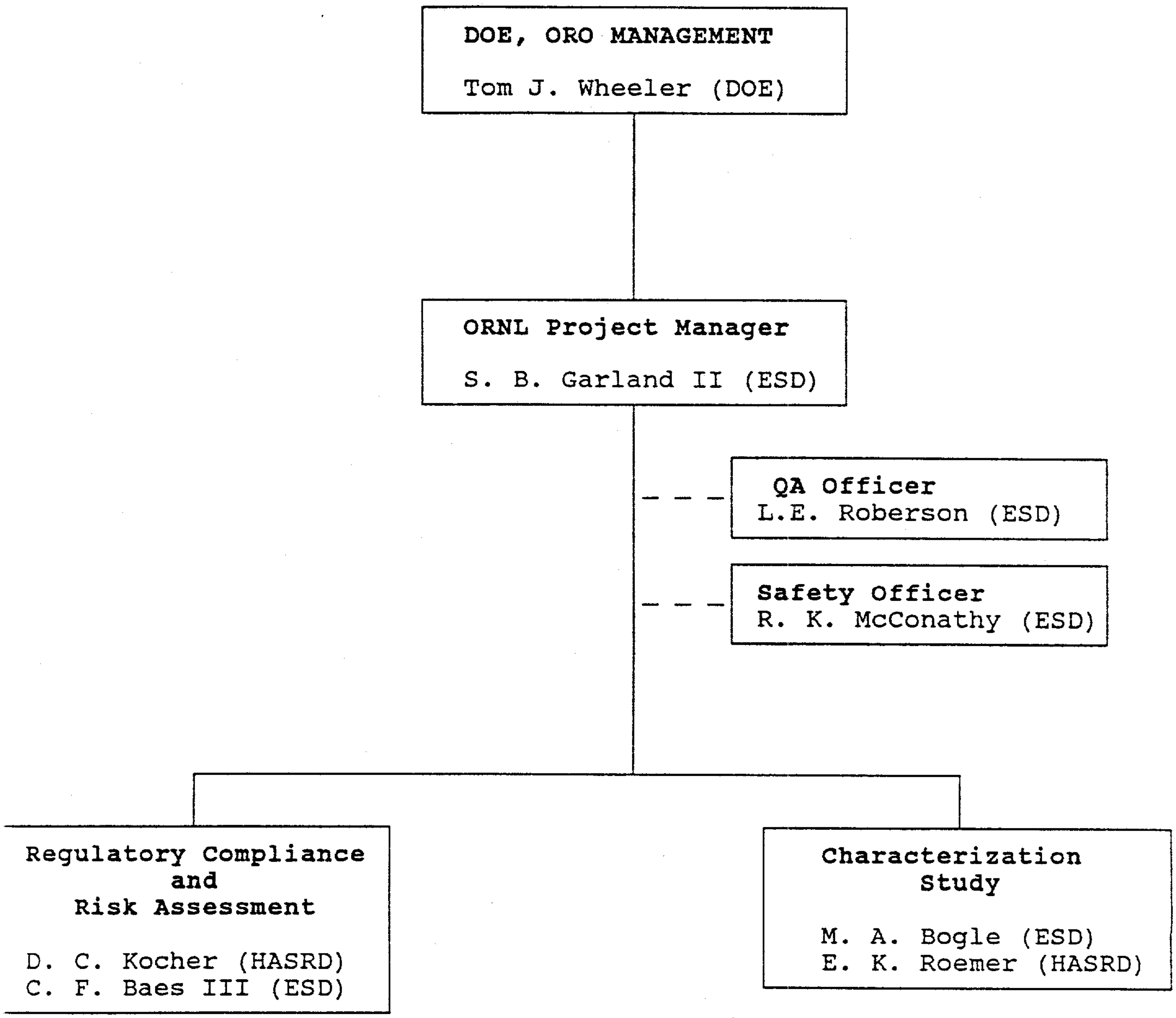
Martin Marietta Energy Systems, Inc. (MMES), 1988. Martin Marietta Energy Systems Environmental Analysis Manual, Oak Ridge Y-12 Plant (in revision).

Myrick, T. E., B. A. Berven, W. D. Cottrell, W. A. Goldsmith and F. F. Haywood, 1987. Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program, ORNL/TM-8600, Oak Ridge National Laboratory.

Oak Ridge Associated Universities (ORAU), 1987. "Radiological Survey of the Railroad Tracks Adjacent to Scarboro Road, Oak Ridge, Tennessee," letter report to the U. S. Department of Energy (February 10).

Attachment 1

ORGANIZATIONAL CHART FOR CSX RAILROAD TRACK PROJECT



ORNL/MAD CHAIN OF CUSTODY RECORD VERSION 1.3 PAGE ______ OF ______
OAK RIDGE NATIONAL LABORATORY, BLDG. 7503, M.S. 6382, P.O. BOX 2008
OAK RIDGE, TENNESSEE 37831-6382 TELEPHONE (615) 576-5212

SITE: ____________ SAMPLE TYPE: ____________ CONTAINER ID: ____________

DATE SEALED: ____________ SEAL TYPE: ____________ SEAL NO: ____________

SAMPLE ID	LOCATION	DATE/TIME	REMARKS

CARRIER: ____________ WAYBILL NO: ____________ DATE: ____________

ORIGIN: ____________ DESTINATION: ____________

	RELINQUISHED BY	DATE/TIME	RECEIVED BY	DATE/TIME
1				
2				
3				
4				

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE ____ OF ____

DATE: ____________ INSTRUMENTS: ____________ ____________ SURVEYORS: ____________

PROPERTY: ____________

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ-SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX. γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS

MARTIN MARIETTA

Internal Correspondence

Attachment 4

MARTIN MARIETTA ENERGY SYSTEMS, INC.

March 20, 1989

M. A. Bogle

Project Safety Summary Comments

Attached is an approved copy of ESD Project Safety Summary (PSS) #8903-02, titled " Characterization and assessment of radiological contamination of the CSX transportation group railroad tracks." Comments from C. H. Miller, Radiation Protection Department, about this work are given at the end of the comments section (#17) of this PSS. Please comply with Miller's requests, or contact him directly (4-6700) if you have questions.

Contact me if I can be of further assistance.

If the nature of the work changes to include hazards not mentioned on this form, please notify me so the existing form can be amended. Thanks for your cooperation.

Ron McConathy

R. K. McConathy, 1505, MS-6035, ORNL (4-7307)

Attachments

cc: S. E. Herbes

ENVIRONMENTAL SCIENCES DIVISION PROJECT SAFETY SUMMARY

(See page 5 for instructions)

"Safety Summary" Form # 8903-02 Date Feb. 27, 1989

1. Responsible Staff Member: MaryAnna Bogle Phone: 4-7824
2. Title of Research: Characterization and Assessment of Radiological Contamination of the CSX Transportation Group Railroad Tracks
3. Location of work: Building ____ Room ____ Field Site CSX Railroad Tracks in Oak Ridge
4. Starting Date: April, 1989 Estimated duration: 2½ - 3 weeks
5. Has a written description of this work been prepared? YES or NO. If YES, attach a copy. If NO give a brief description of the research.

(See attached work plan)

6. List hazardous chemicals (toxic, teratogens, carcinogens, etc.) and/or radioisotopes to be used. Include quantity, concentration, activity, and chemical form for each chemical/radioisotope as applicable. Also provide values for stock and diluted/working materials. (Continue as needed to #17)

Not Applicable

Hazardous Chemical/Isotope	Chemical Form	Concentration/ Activity	Quantity Used	MSDS Available?
				YES or NO
				YES or NO
				YES or NO
				YES or NO

7. List the name and badge number of personnel who will be involved in the use of the above chemicals and/or radioisotopes:

Not Applicable

8. Has an ESD Mini Waste Management Plan been prepared for this work? YES or NO. (If NO, see the ESD Environmental Protection Officer or Radiation Control Officer to obtain the form to fill out.)

Not applicable - See section on waste management in work plan.

(12/15/87)

Attachment 4

2

ORNL (Martin-Marietta)

9. Will personnel other than ~~ESD~~ employees (e.g. students, guests, etc.) be working on this project. YES or NO. If YES, have they been oriented to:

ESD safety procedures?	YES or NO
ESD waste disposal procedures?	YES or NO
Radioisotope use procedures?	YES or NO or N/A

List their names and badge numbers below:

10. Have research personnel received the required training to be proficient in recognizing and dealing with the hazards associated with this work? This training should include safety, radioisotope, and waste disposal training. YES or NO. If NO, describe the training needed.

The Measurement, Applications, and Development Group of HASRD will be conducting the survey and sampling work. The staff of this group routinely conduct radiological surveys for DOE around the country and have the required training and experience to deal with any hazards associated with this type work.

11. List the safety equipment needed to perform this research?

See safety section of work plan.

12. Will respirators be required as safety equipment for this project. YES or NO. If YES, list the names of those who will use a respirator and the date they received their Industrial Hygiene training/authorization for respirator use.

Date:

Date:

13. Are there health hazards associated with this research work? YES or NO. If YES, give a brief description of the procedures, equipment, and containment that will be used to minimize the health hazards.

Protective clothing and ~~dosag~~ dosage monitoring (refer to safety plan).

14. How will radiation and contamination zones be established and marked? Where will these zones be located? (See the Health Physics Procedure Manual, Procedures 2.3 and 2.7 for help.)

Concentrations (or exposures) are expected to be well below levels which require zones.

15. List the isotopes to be used and fill in the requested information. (See the Health Physics Procedure Manual, Appendix A-7 (*) for help in filling in the requested information.) Not Applicable

Isotope	Radiotoxicity Class *	Radiation Quantity Handled (Ci)	Modifying Factor *	Lab. Type Required *

16. Is field work planned as a part of this project? YES or NO.

If YES, have all field work personnel read the "ESD Radio Use Procedure." YES or NO. Not Applica
Field personnel are from Health and Safety Research Division and will carry cellular phones.

Will the field work be in radiation/contamination zones? YES or NO.
Don't know but possibly.

If YES, have personnel been trained in the proper procedures for clearing through Health Physics after working in these areas? YES or NO.

If YES, are there pocket dosimeters available for use by each working group when required? YES or NO.

17. Continuations & comments:

The field work for this project involves a radiological survey of the CSX railroad tracks passing through Oak Ridge in order to identify any radioactive contamination along the track right-of-way. Samples will be collected for analysis if areas are located with radiation levels greater than twice the normal background level. It's entirely feasible that no contamination will be located along the stretch surveyed in which case no samples will be collected.

As mentioned in answer 10 above, the MAD group of HASRD have extensive experience in surveying for DOE radioactively contaminated sites and thus are very familiar with appropriate safety requirements. Section

4

17. (continued)

17 of the RASA Procedures Manual referenced in the work plan outlines procedures to be used for monitoring equipment and personnel for contamination, procedures for decontamination of equipment and personnel in the event of contamination, and procedures for personnel exposure monitoring and protection.

As mentioned in the work plan, the field crew will designate a member to serve as a look-out. The sole responsibility of this person will be to monitor any train activity and to alert, using a whistle or air horn, the survey crew to any hazards. The field crew will carry cellular phones for contacting the ORNL shift supervisor in the event of an emergency.

C.H. Miller Comments: (1) Public Relations Dept. should be informed of this project so as to minimize adverse press releases. (2) Any samples from contaminated sites should be tagged in accordance with ORNL HP Procedure 4.1 prior to delivery to Anal. Chem.

APPROVALS

			Detailed Safety Plan ?
Principal Investigator:	[illegible]	Date: 7 Mar 89	YES NO
Section Head:	[illegible]	Date: 3-9-89	YES NO
(see comments above) Health Physics:	C.H. Miller	Date: 3-12-89	YES NO
Industrial Hygiene:		Date:	YES NO
Industrial Safety:	[illegible]	Date: 3-13-89	YES NO
ESD DSO/RCO:	[illegible]	Date: 3/20/89	YES NO

Detailed Safety Plan Required: YES NO

APPENDIX B

FIELD DATA SHEETS FROM WALKOVER GAMMA SURVEY

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 1 OF 3

DATE: 3/7/90

PROPERTY: CSX R.R.
MAIN LINE

INSTRUMENTS: 80
74
57

SURVEYORS: EKR
MEM
SMF
DSL

REGION J

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ-SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX. γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
0,0	4	5	4-5	-	N/A	N/A	N/A	NONE BKGD
50,0	4	5	4-5	-	"	"	"	"
* 600,0SE	4.5	22	10-22	R.R. TIE	"	"	"	SMALL AREA <1m² SEEMS TO BE R.R. TIE INVOLVEMENT.
100,0	3.5	4	3-4	-	"	"	"	NONE BKGD
150,0	3.5	4	3-4	-	"	"	"	"
200,0	4	4	3-4	-	"	"	"	"
250,0	3	4	3-4	-	"	"	"	"
300,0	4	4	3-4	-	"	"	"	"
350,0	3	3	3-4	-	"	"	"	"
400,0	3	3.5	3-4	-	"	"	"	"
450,0	3	4	3-4	-	"	"	"	"
500,0	3	4	3-4	-	"	"	"	"
550,0	3	4	3-4	-	"	"	"	"
600,0	3	4	2-4.5	-	"	"	"	"
700,0	2.5	4	2-4.5	-	"	"	"	"
800,0	2.5	4	2-4.5	-	"	"	"	"

* - ELEVATED REGIONS

INFO ON PLATE 1, FIG 1

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY
OUTDOOR DATA SHEET

PAGE 2 OF 3

DATE: 3/7/90

INSTRUMENTS: 80, 74, 57

PROPERTY: CSX R.R. MAIN LINE

SURVEYORS: EKR, MEM, SMF, DSC

	GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ-SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m	SURFACE	β-γ CPM OPEN	CLOSED	SOIL SAMPLE NO.	REMARKS
	900,0	2.5	3	2-4.5	–	N	A	N/D		N/A	GENERAL BKGD
	1000,0	2.5	3	2-4.5	–	"		"		"	"
	1100,0	3	3	2-4.5	–	"		"		"	"
	1200,0	3	4	2-4.5	–	"		"		"	"
	1300,0	4	3	2-4.5	–	"		"		"	"
	1400,0	4	3	2-4.5	–	"		"		"	"
	1500,0	4	4	2-4.5	–	"		"		"	"
	1600,0	2.5	3	2-4.5	–	"		"		"	"
	1700,0	3	3	2-4.5	–	"		"		"	"
	1800,0	3	3	2-4.5	–	"		"		"	"
	1900,0	3	3	2-4.5	–	"		"		"	"
*	1900,4N	7.5	7.0	7-7.5	BRICKS	"		"		"	PILE OF BRICKS (EMANATION) ‡
*	2000,0	7.5	6.0	6-7.5	–	"		"		"	GAMMA INCREASES AS WE MOVE TOWARDS THE NORTH ‡
*	2000,6N	10.0	10.0	9-10.0	OFF BALAST	"		"		"	‡
*	2100,0	20.0	18.0	15-20	–	"		"		"	‡
*	2100,30N	30.0	30.0	25-30	NEXT TO FENCE	"		"		"	‡

‡ - THIS GENNERAL REGION APPEARS TO BE EMINATION FROM THE "QUADREX" INC. TO THE NORTH OF THE TRACKS. MULTIPLE 55 gal DRUMS w/ RADIOACTIVE AND 2 mR/h LABELS.

* - ELEVATED REGIONS

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY
OUTDOOR DATA SHEET

PAGE 3 OF 3

DATE: 3/7/90
INSTRUMENTS: 80, 74, 57
PROPERTY: CSX R.R. MAIN LINE
SURVEYORS: EKR, MEM, SMF, DSL

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
* ‡ 2200,0	55	45	45-55	ON BALAST	N/A	N/A	3300 3301	‡ SAMPLED @ ~2175, 5N;
* ‡ 2200,30N	100	100	100K	ALONG FENCE	"	"	3302 3304	NEXT TO THE QUADREX 2175, IN FENCE. TAKEN FOR SCREENING
* ‡ 2300,0	22	20	18-22	ON BALAST	"	"		PURPOSES ONLY. NOT QUANTITATIVE. GENERAL BKG(?)
* ‡ 2400,0	7	6	4-6	OK	"	"	NONE	"
2500,0	5	5	4-5	"	"	"	"	"
2600,0	5	5	4-5	"	"	"	"	"
2700,0	4	5	4-5	"	"	"	"	"
2800,0	4	4	4-5	"	"	"	"	"
2900,0	3	4	4-5.5	"	"	"	"	"
3000,0	4	4	4-6	"	"	"	"	"
3100,0	4	5	4-6	"	"	"	"	"
3200,0	4	6	4-6	"	"	"	"	"
3300,0	4	5.5	4-5.5	"	"	"	"	"
3400,0	3.5	5.5	4-5.5	"	"	"	"	"
—			END OF	DAY		"	"	"

‡ - THIS GENERAL REGION APPEARS TO BE EMINATION FROM THE "QUADREX INC" TO NORTH OF THE TRACKS. MULTIPLE 55gal DRUMS w/ RADIOACTIVE AND 2 mR/h SIGNS.

* - ELEVATED REGIONS

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 1 OF 2

DATE: 3/8/90

PROPERTY: CSX RAILROAD MAINLINE

INSTRUMENTS: 80, 74, 57

SURVEYORS: EKR, MEM, DSL, SMF

	GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ-SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX. γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
	3400,0	3.5	4.0	3-5	–	N/A	N/A	N/A	IGNEOUS
*	3480,1E	3.5	12	12	ONE ROCK	"	"	"	RED ~~IGNEOUS~~ STONE - LEFT IN PLACE
	3500	3.0	5.0	3-5		"	"	"	GENERAL BKGD
	3600	3.0	5.0	3-6		"	"	"	"
	3700	3.0	6.6	3-6		"	"	"	"
	3800	4.0	5.5	3-6		"	"	"	"
	3900	4.0	6.0	3-6		"	"	"	"
	4000	4.0	6.0	3-6		"	"	"	"
	4100	3.0	6.0	3-6		"	"	"	"
	4200	3.0	6.0	3-6		"	"	"	"
	4300	3.5	6.0	3-6		"	"	"	"
	4400	3.5	5.5	3-6		"	"	"	"
	4500	4.0	5.5	3-6		"	"	"	"
	4600	4.0	5.5	3-6		"	"	"	"
* ‡	4664,2N	5.0	10	7-11	DIFFERENT ROCK TYPE		"		BALLAST OF A DIFFERENT TYPE! ~~IGNEOUS~~ STONES FROM 4664-4750 DOLOMITIC
* ‡	4700,0	5.0	10	6-10	"		"		

IDENTIFIED RX AS FINE CRYSTALINE DOLOMITE.

* - ELEVATED READINGS

‡ - BALLAST APPEARS TO BE DIFFERENT FROM PREVIOUS SURVEYS. ROCK LOOKS LIKE GREY DOLOMITE ~~OR IGNEOUS~~ STONES. AREA 4664-4750 ON SIDES OF TRACK ONLY - SEE MAP!

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 2 OF 2

DATE: 3/8/90

PROPERTY: CSX RAILROAD MAIN LINE

INSTRUMENTS: 80 / 74 / 57

SURVEYORS: EKR / MEM / DSC / SMF

	GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX. γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
* ǂ	4750, 2N	5	10	6-10	DIFFERENT ROCK TYPE	N/A	N/A	NONE	BALLAST OF A DIFFERENT TYPE. ~~[illegible]~~ STONES FROM 4664-4780
	4800, 0	4.0	5.0	3-6	OK	"	"	"	DOLOMITIC EKR
				END OF DAY			"	"	

* - ELEVATED READINGS

ǂ - SEE PAGE 1 OF 2

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY
OUTDOOR DATA SHEET

PAGE 1 OF 2

DATE: 3/9/90

PROPERTY: CSX R.R. MAIN LINE

INSTRUMENTS: 80, 74, 57

SURVEYORS: EKR, MEM, SMF, DSL

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
4800.0	3	3.5	2.5-5.0	N/A	N/A	N/A	NONE	BKGD
4900.0	3	3.5	2.5-5.0	"	"	"	"	"
5000.0	3	4	2.5-5.0	"	"	"	"	"
5100.0	3.5	4	2.5-5.0	"	"	"	"	"
5200.0	3	4	2.5-5.0	"	"	"	"	"
5300.0	3	3.5	2.5-5.0	"	"	"	"	"
5400.0	2.5	3.5	2.5-5.0	"	"	"	"	"
5500.0	2.5	3.5	2.5-5.0	"	"	"	"	"
5600.0	3	4	2.5-5.0	"	"	"	"	"
5700.0	3	4	2.5-5.0	"	"	"	"	"
5800.0	3	4	2.5-5.0	"	"	"	"	"
5900.0	3	4	2.5-5.0	"	"	"	"	"
6000.0	3.5	4.5	2.5-5.0	"	"	"	"	"
6100.0	3	4.0	2.5-5.0	"	"	"	"	"
6200.0	3	4.0	2.5-5.0	"	"	"	"	"
6300.0	3	4.0	2.5-5.0	"	"	"	"	"

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY
OUTDOOR DATA SHEET

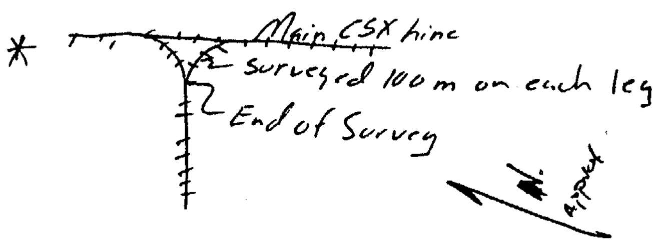
PAGE 2 OF 2

DATE: 3/9/90
PROPERTY: CSX R.R. MAIN LINE
INSTRUMENTS: 80, 74, 57
SURVEYORS: EKR, MEM, SMF, DJC

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ-SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX. γ	GRID BLOCK MAX γ 10^3 CPM 1m/SURFACE	β-γ CPM OPEN/CLOSED	SOIL SAMPLE NO.	REMARKS
6400.0	3	3.5	2.5-5.0	N/A	N/A	N/A	NONE	GENERAL BKGD
6500.0	2.5	3.0	2.5-5.0	"	"	"	"	"
6600.0	2.5	3	2.5-5.0	"	"	"	"	"
6700.0	3	4	2.5-5.0	"	"	"	"	"
6800.0	3	4	2.5-5.0	"	"	"	"	"
6900.0	3	4	2.5-5.0	"	"	"	"	"
6931.0	3.5	4	2.5-5.0	"	"	"	"	"
(Track intersection to main line @ ELZA Gate						"	"	End of official survey
100.0 R	3	3.5	2.5-5.0	"	"	"	"	Surveyed 100 meters on each
100.0 L	3	3.5	2.5-5.0	"	"	"	"	leg of y to main ~~track~~ track *

EKR 3/9/90

*



OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY
OUTDOOR DATA SHEET

PAGE 1 OF 1

DATE: 3/9/90
PROPERTY: CSX R.R. Siding A
INSTRUMENTS: 80, 74, 57
SURVEYORS: EKR, MEM, SME, DSL

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT (10^3 CPM) 1 METER	GRID POINT READINGS γ SCINT (10^3 CPM) SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
0,0	2.5	3.5	2.5-5.0	N/A	N/A	N/A	N/A	BEH BKGD
100,0	2.5	3	2.5-5.0	"	"	"	"	"
200,0	3	2.5	2.5-5.0	"	"	"	"	"
300,0	3	3.5	2.5-5.0	"	"	"	"	"
400,0	3	3.5	2.5-5.0	"	"	"	"	"
500,0	3	3	2.5-5.0	"	"	"	"	"
600,0	2.5	3.5	2.5-5.0	"	"	"	"	"
700,0	2.5	4	2.5-5.0	"	"	"	"	"
800,0	3	4	2.5-5.0	"	"	"	"	End of Siding A where track intersects main line
			EKR 3/9/90					

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 1 OF 2

DATE: 6/26/90 INSTRUMENTS: 132

PROPERTY: CSX R.R. SIDING "B"

SURVEYORS: EKR, DJT, SMF

REGIONS	GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT (10³ CPM) 1 METER	SURFACE	γ-SCAN RANGE (10³ CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10³ CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
	0, 0	4	5	4-5			N/A	N/A	BKGD
	50, 0	4	4	4-6			N/A	N/A	BKGD
A	72-74, 0-1	40	200	10-200	R.R. BALLAST		N/A	N/A	2 m^2
B	80-81, 0-1N	4	15	7-15			N/A	N/A	2 m^2
C	82-85, 2S	41	200	7-200			N/A	N/A	5 m^2
D	90-91, 0	20	75	7-75			N/A	3305	3 m^2
E	100-105, 2N	50	800	7-800			N/A	3308/3311 3309 3310	17 m^2
F	109-111, 0	25	100	7-100			N/A	N/A	3 m^2
G	115-124, 5N	68	800	7-800			OPEN 1.7 mR	3312 3313/3314	59 m^2
	150, 0	4	5	4-6			N/A	N/A	BKGD
	200, 0	4	5.5	4-6			N/A	N/A	BKGD
H	248-250, 0	200	200	7-200			N/A	N/A	3 m^2
I	248-256, 5N	5	12	7-12			N/A	3306 3307	16 m^2
	300, 0	4	6	4-6			N/A	N/A	BKGD
	350, 0	5	6	4-6			N/A	N/A	BKGD
	400, 0	5	6	4-6			N/A	N/A	BKGD

HCM

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 2 OF 2

DATE: 6/21/90 INSTRUMENTS: 132

PROPERTY: CSX R.R.
SIDING "B"

SURVEYORS: EKR
DJT
SMF

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β - γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
450,0	5	6	4 - 6	N/A	N/A "	N/A	N/A	GENERAL BKGD
500,0	4	6	4 - 6	"	"	"	"	
550,0	4	6	4 - 6	"	"	"	"	
600,0	5	6	4 - 6	"	"	"	"	
650,0	5	6	4 - 6	"	"	"	"	
700,0	6	6	4 - 6	"	"	"	"	
750,0	6	6	4 - 6	"	"	"	"	
				END				

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 1 OF 1

DATE: 3/5/90

PROPERTY: CSX R.R. Siding C

INSTRUMENTS: 80, 74, 57

SURVEYORS: EKR, MEM, SMF, DSL

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM (1m/SURFACE)	β-γ CPM OPEN/CLOSED	SOIL SAMPLE NO.	REMARKS
0.0	2.5	3.5	2.5-5.0	N/A	N/A	N/A	NONE	GENERAL BKGD
100.0	3	3.5	2.5-5.0	"	"	"	"	"
200.0	3	4.0	2.5-5.0	"	"	"	"	"
300.0	3	3.5	2.5-5.0	"	"	"	"	"
400.0	2.5	3	2.5-5.0	"	"	"	"	"
500.0	3	3	2.5-5.0	"	"	"	"	"
600.0	3	3.5	2.5-5.0	"	"	"	"	"
700.0	3	3.5	2.5-5.0	"	"	"	"	"
761.0	2.5	3	2.5-5.0	"	"	"	"	Intersection of siding C w/main track

EKR
3/9/90

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 1 OF 2

DATE: 3/12/90

PROPERTY: CSX R.R Siding D

INSTRUMENTS: 57, 42, 80

SURVEYORS: ~~[illegible]~~ EKR, MEM, SMF, DSL

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
0, 0	3.5	4	1.5-6	Low BKGD	N/A	N/A	NONE	Wide variation is Bkgd
100, 0	3	3.5	1.5-6	"	"	"	"	readings caused by variations
200, 0	3	3.5	1.5-6	"	"	"	"	in ballast rock types
300, 0	2.5	3	1.5-6	"	"	"	"	varying from met-is-carb
400, 0	3	3.5	1.5-6	"	"	"	"	rock MEM
500, 0	3	3.5	1.5-6	"	"	"	"	
600, 0	3	3.5	1.5-6	"	"	"	"	Low BKGD - EKR
700, 0	3	4	1.5-6	"	"	"	"	"
800, 0	3.5	4	1.5-6	"	"	"	"	"
900, 0	3.5	4	1.5-6	"	"	"	"	"
1000, 0	4	4.5	1.5-6	"	"	"	"	"
1100, 0	4	5.5	1.5-6	"	"	"	"	"
1200, 0	4	6	1.5-6	"	"	"	"	"
1300, 0	1.5	2.0	1.5-6	"	"	"	"	Approx location of ballast
1400, 0	1.5	2.0	1.5-6	"	"	"	"	change, lowered Bkgd readings
1500, 0	1.5	2.0	1.5-6	"	"	"	"	then going back to higher

readings in the met. ballast.

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE 2 OF 2

DATE: 3/12/90

PROPERTY: CSX R.R Siding D

INSTRUMENTS: 57, 42, 80

SURVEYORS: EKR, MEM, SMF, DSL

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ - SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS
1600.0	2.0	3.0	1.5-6	Low BKGD	N/A	N/A	NONE	Low BKGD See sheet 1.
1635.0	3.5	4.0	1.5-6	"	"	"	"	End of Siding D

EKR 3/12/90

APPENDIX C

RESULTS OF VICINITY PROPERTY SURVEYS

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

GRAND JUNCTION OFFICE
P. O. BOX 2567
GRAND JUNCTION, COLORADO 81502

August 6, 1990

Mr. Tom J. Wheeler
U. S. Department of Energy
Environmental Restoration Division
P.O. Box 2001
Oak Ridge, Tennessee 37831-8541

Dear Mr. Wheeler

Location Number:	OR00003
Location Address:	131 Claremont Road
	Oak Ridge, Tn. 37830
Date of Issue:	July 17, 1990
Survey Date:	June 27, 1990
Team Leader:	E.K. Roemer

ORNL/GJ EXCLUSION REPORT
Health and Safety Research Division
Work performed as part of the CSX Railroad Survey

This radiological survey assessment was conducted using methods as defined in the (DRAFT) POLLUTANT ASSESSMENTS GROUP PROCEDURES MANUAL. A complete gamma screening revealed no elevated reading above the general background. This property is recommended for exclusion from further consideration by the CSX project based on exposure rates promulgated in DOE Order 5400.5.

Supporting graphics are attached. Data are as follows:

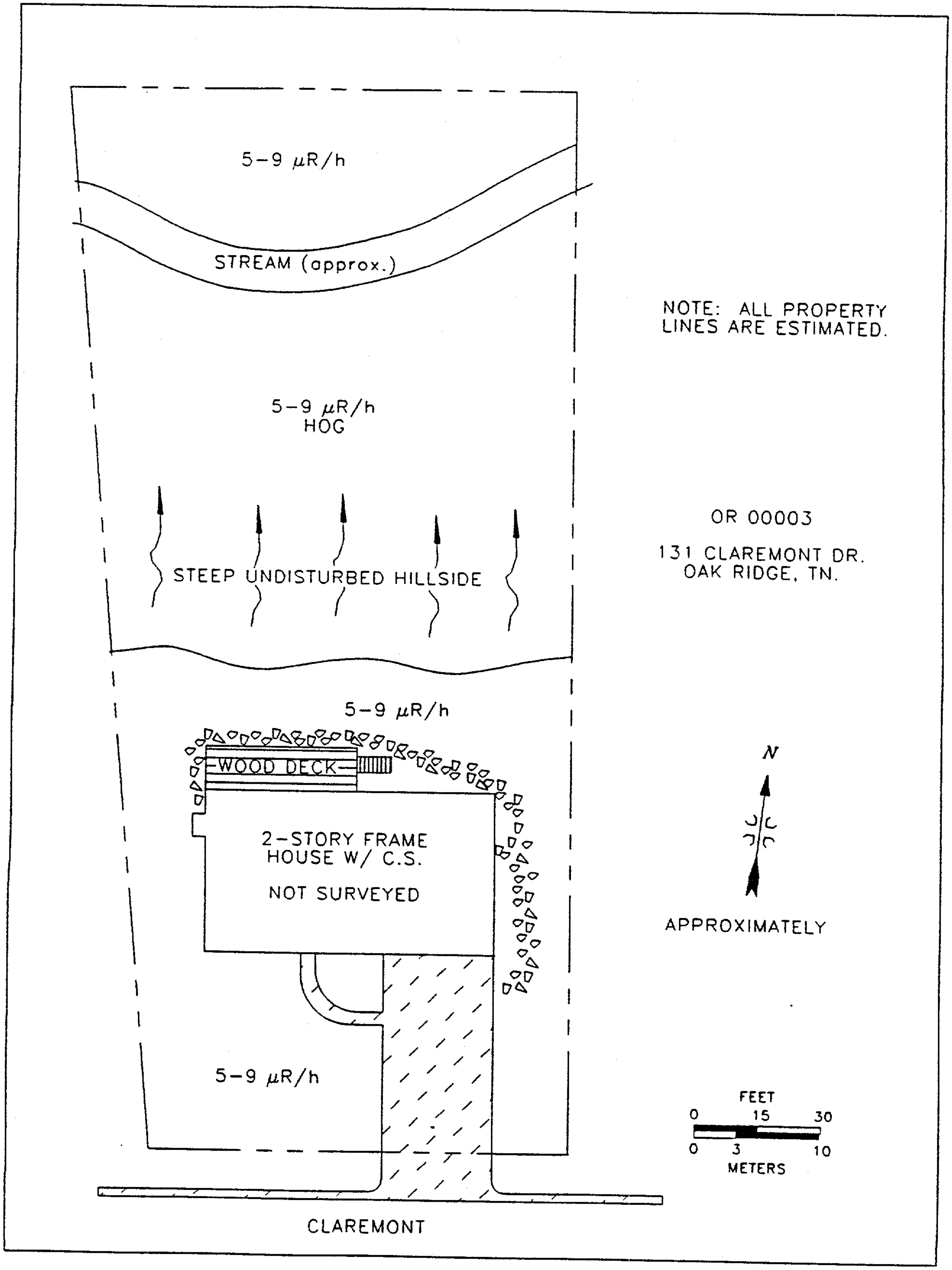
-Owner Information-
Owner Name(s): Mr./Mrs. Randy L. Gardner
Owner Address: 131 Claremont Rd.
Oak Ridge, Tn. 37830

-Outdoor Screening Data-

Exposure Rate Range(s):	5-9 uR/h
Background Exposure Rate:	5-10 uR/h
High Outdoor Gamma (HOG):	9.0 uR/h
Point Source (*):	None uR/h

Comments: The scanning coverage was limited in areas of steep hillside and dense vegetation.

Sincerely,
Douglas K. Halford
Douglas K. Halford
Radiation Projects Manager



EKR 6/27/90 EKR 7/9/90

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

GRAND JUNCTION OFFICE
P. O. BOX 2567
GRAND JUNCTION, COLORADO 81502

August 6, 1990

Mr. Tom J. Wheeler
U. S. Department of Energy
Environmental Restoration Division
P.O. Box 2001
Oak Ridge, Tennessee 37831-8541

Dear Mr. Wheeler

Location Number:	OR00001
Location Address:	137 Claremont Road
	Oak Ridge, Tn. 37830
Date of Issue:	July 17, 1990
Survey Date:	June 27, 1990
Team Leader:	E.K. Roemer

ORNL/GJ EXCLUSION REPORT
Health and Safety Research Division
Work performed as part of the CSX Railroad Survey

This radiological survey assessment was conducted using methods as defined in the (DRAFT) POLLUTANT ASSESSMENTS GROUP PROCEDURES MANUAL. A complete gamma screening revealed no elevated reading above the general background. This property is recommended for exclusion from further consideration by the CSX project based on exposure rates promulgated in DOE Order 5400.5.

Supporting graphics are attached. Data are as follows:

-Owner Information-
Owner Name(s): Mr./Mrs. Larry Keane
Owner Address: 137 Claremont Rd.
Oak Ridge, Tn. 37830

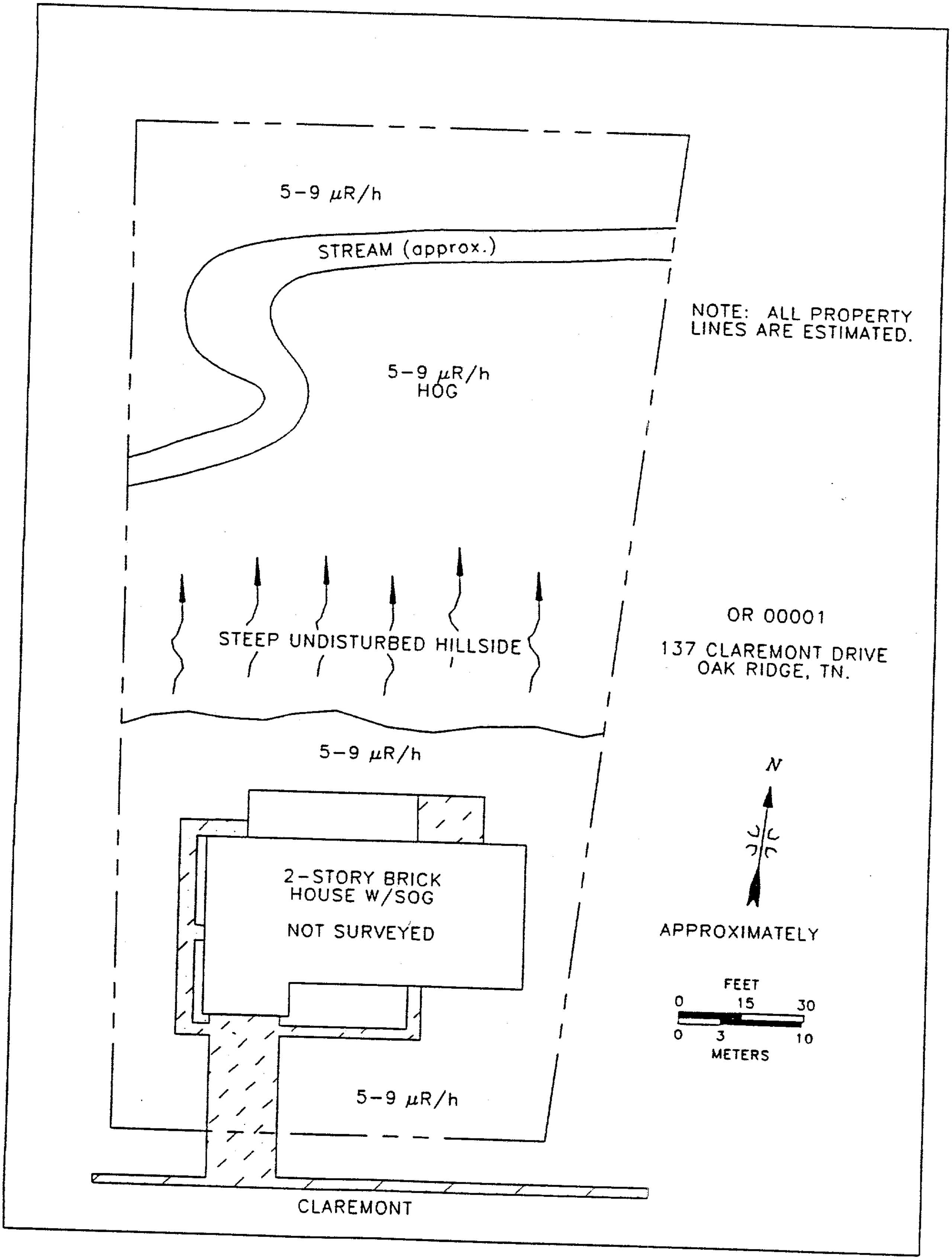
-Outdoor Screening Data-

Exposure Rate Range(s):	5-9 uR/h
Background Exposure Rate:	5-10 uR/h
High Outdoor Gamma (HOG):	9.0 uR/h
Point Source (*):	None uR/h

Comments: The scanning coverage was limited in areas of steep hillside and dense vegetation.

Sincerely,

Douglas K. Halford
Radiation Projects Manager



EKR 6/27/90 EKR 7/9/90

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

GRAND JUNCTION OFFICE
P. O. BOX 2567
GRAND JUNCTION, COLORADO 81502

August 6, 1990

Mr. Tom J. Wheeler
U. S. Department of Energy
Environmental Restoration Division
P.O. Box 2001
Oak Ridge, Tennessee 37831-8541

Dear Mr. Wheeler

Location Number:	OR00002
Location Address:	133 Claremont Road
	Oak Ridge, Tn. 37830
Date of Issue:	July 17, 1990
Survey Date:	June 27, 1990
Team Leader:	E.K. Roemer

ORNL/GJ EXCLUSION REPORT
Health and Safety Research Division
Work performed as part of the CSX Railroad Survey

This radiological survey assessment was conducted using methods as defined in the (DRAFT) POLLUTANT ASSESSMENTS GROUP PROCEDURES MANUAL. A complete gamma screening revealed no elevated reading above the general background. This property is recommended for exclusion from further consideration by the CSX project based on exposure rates promulgated in DOE Order 5400.5.

Supporting graphics are attached. Data are as follows:

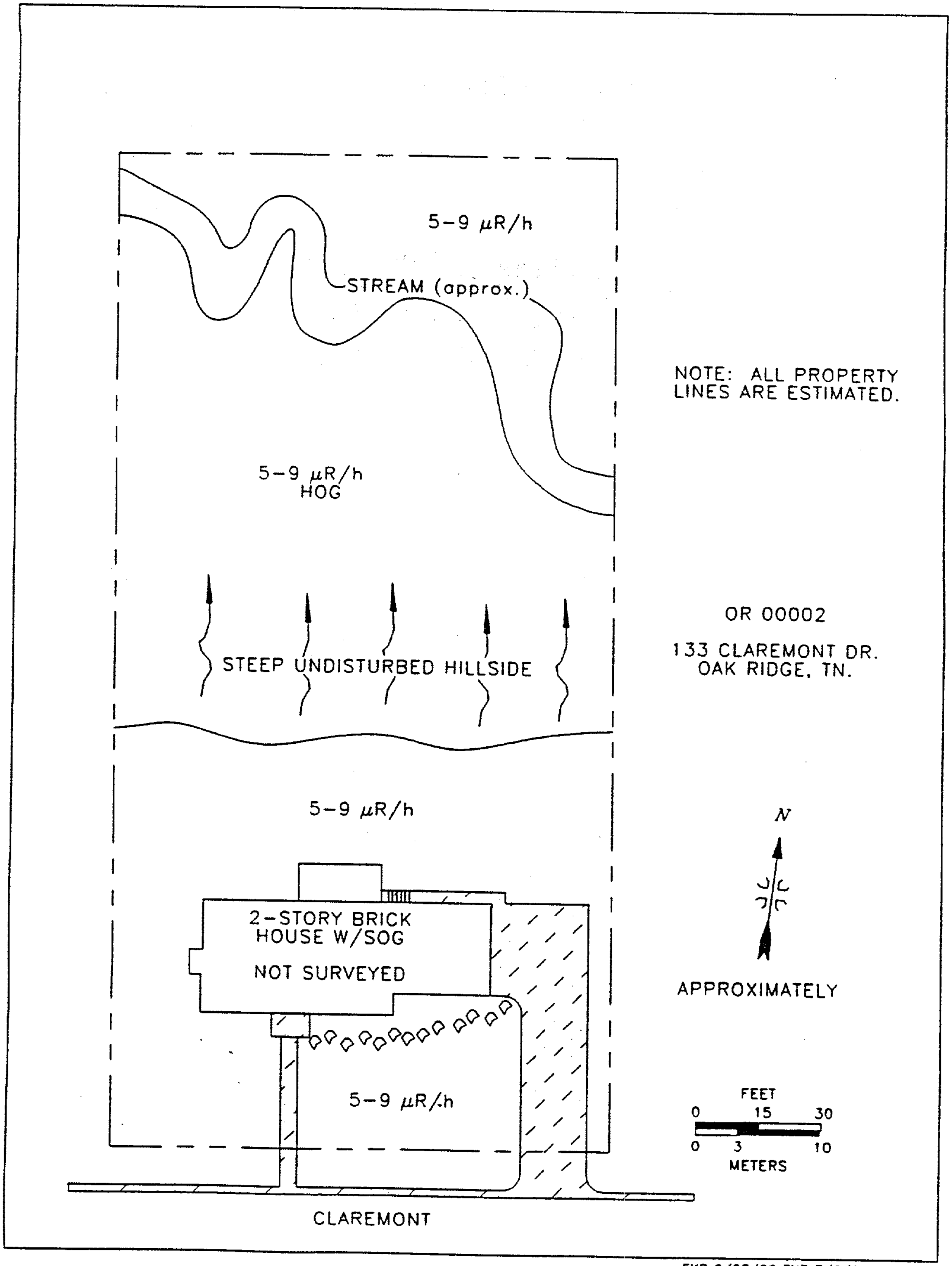
-Owner Information-
Owner Name(s): Mr./Mrs. Maurice R. Richardson
Owner Address: 133 Claremont Rd.
Oak Ridge, Tn. 37830

-Outdoor Screening Data-

Exposure Rate Range(s):	5-9 uR/h
Background Exposure Rate:	5-10 uR/h
High Outdoor Gamma (HOG):	9.0 uR/h
Point Source (*):	None uR/h

Comments: The scanning coverage was limited in areas of steep hillside and dense vegetation.

Sincerely,
Douglas K. Halford
Douglas K. Halford
Radiation Projects Manager



EKR 6/27/90 EKR 7/9/90

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PLATE 1

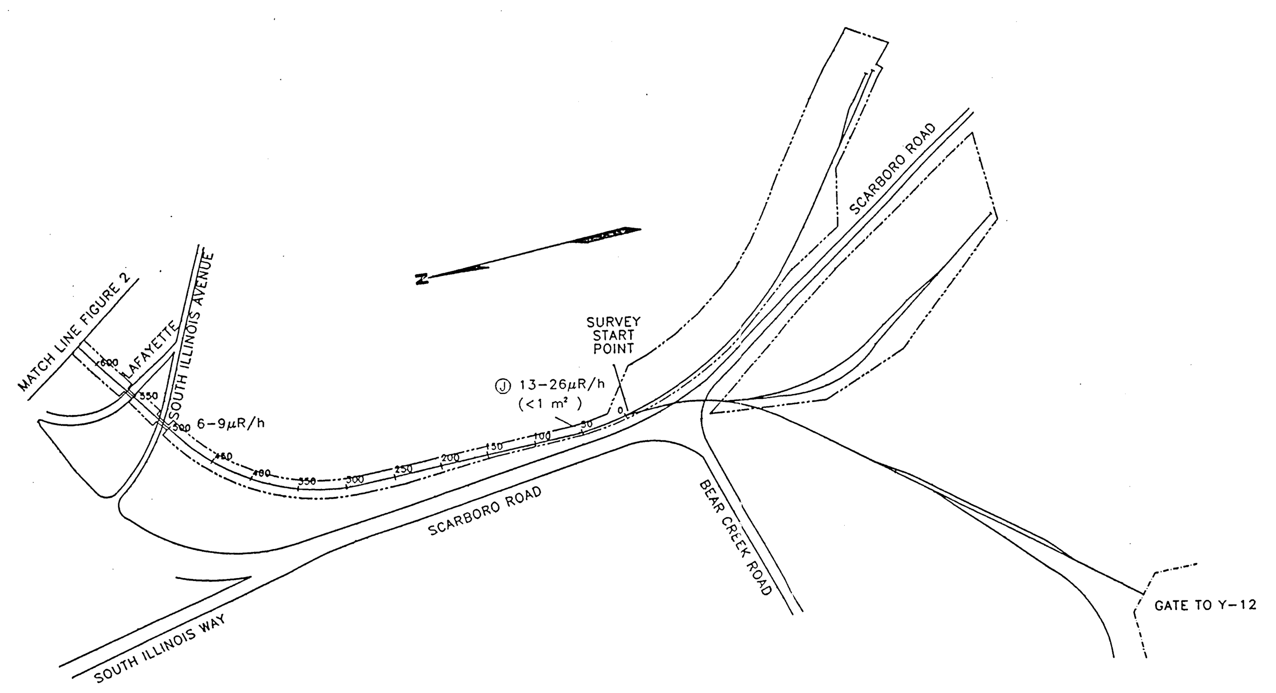

FIGURE 1

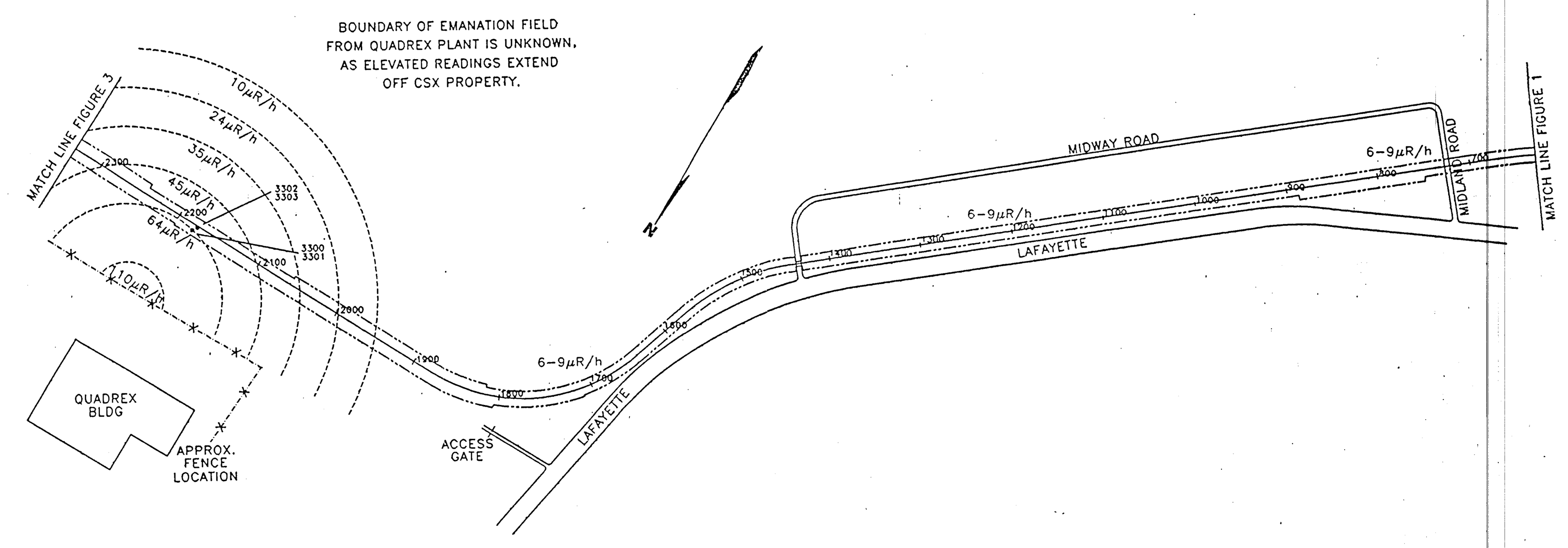

FIGURE 2

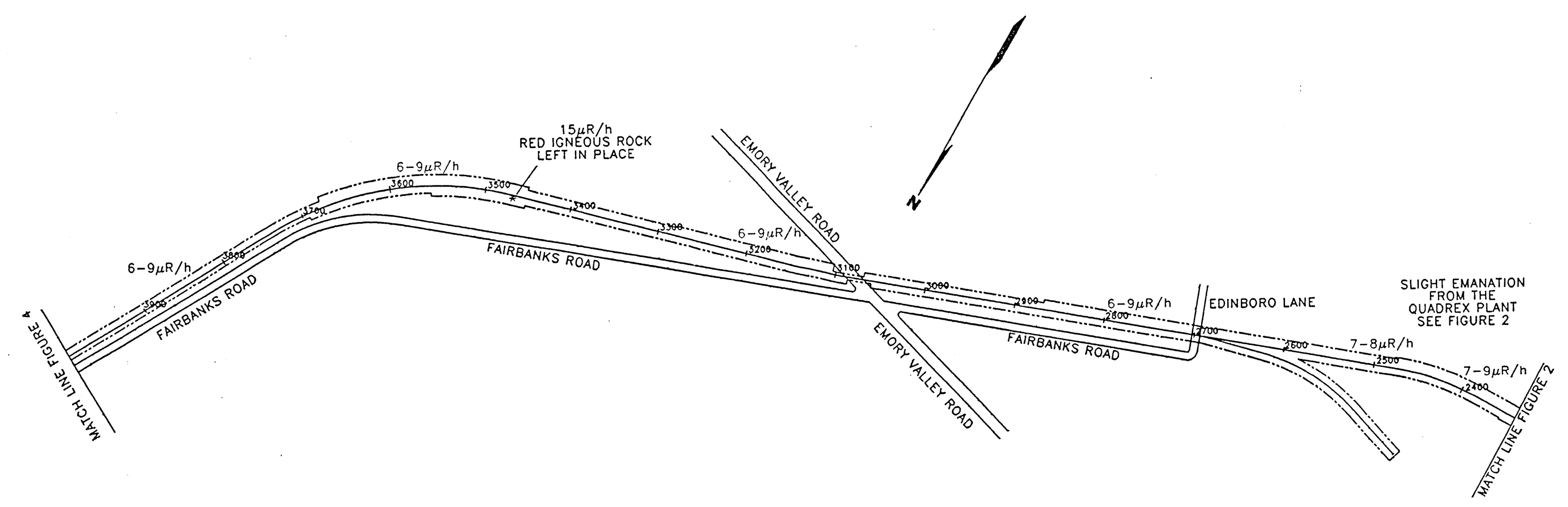

FIGURE 3

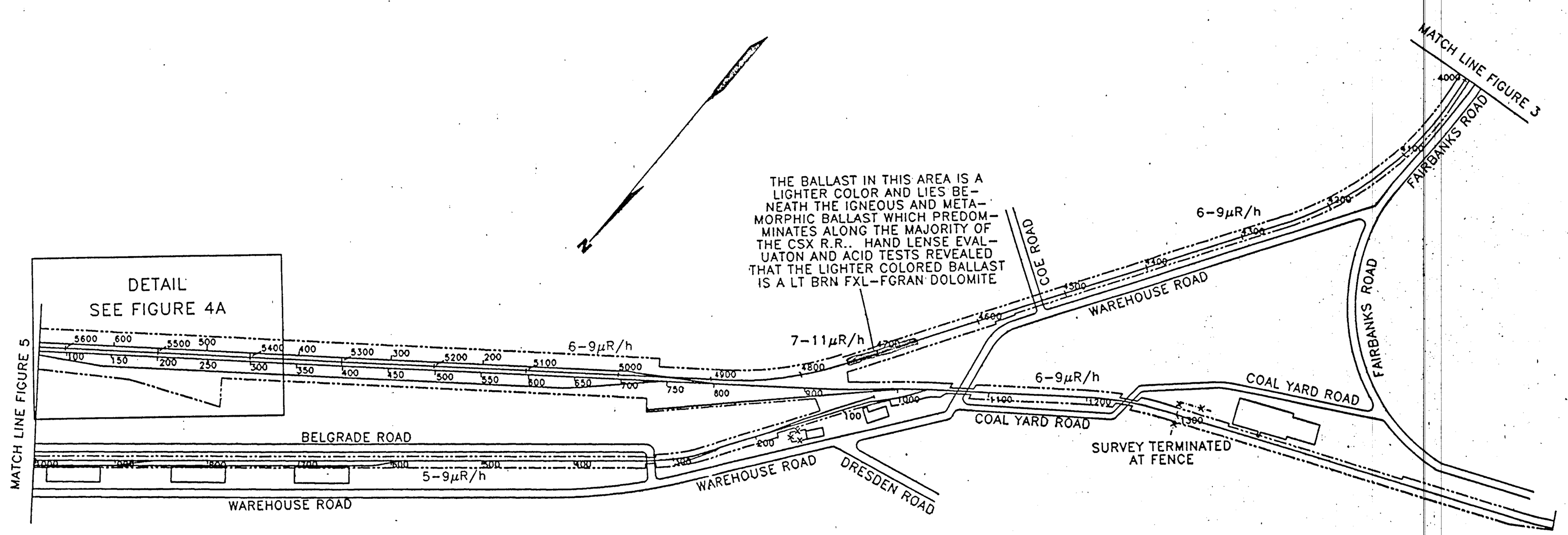

FIGURE 4

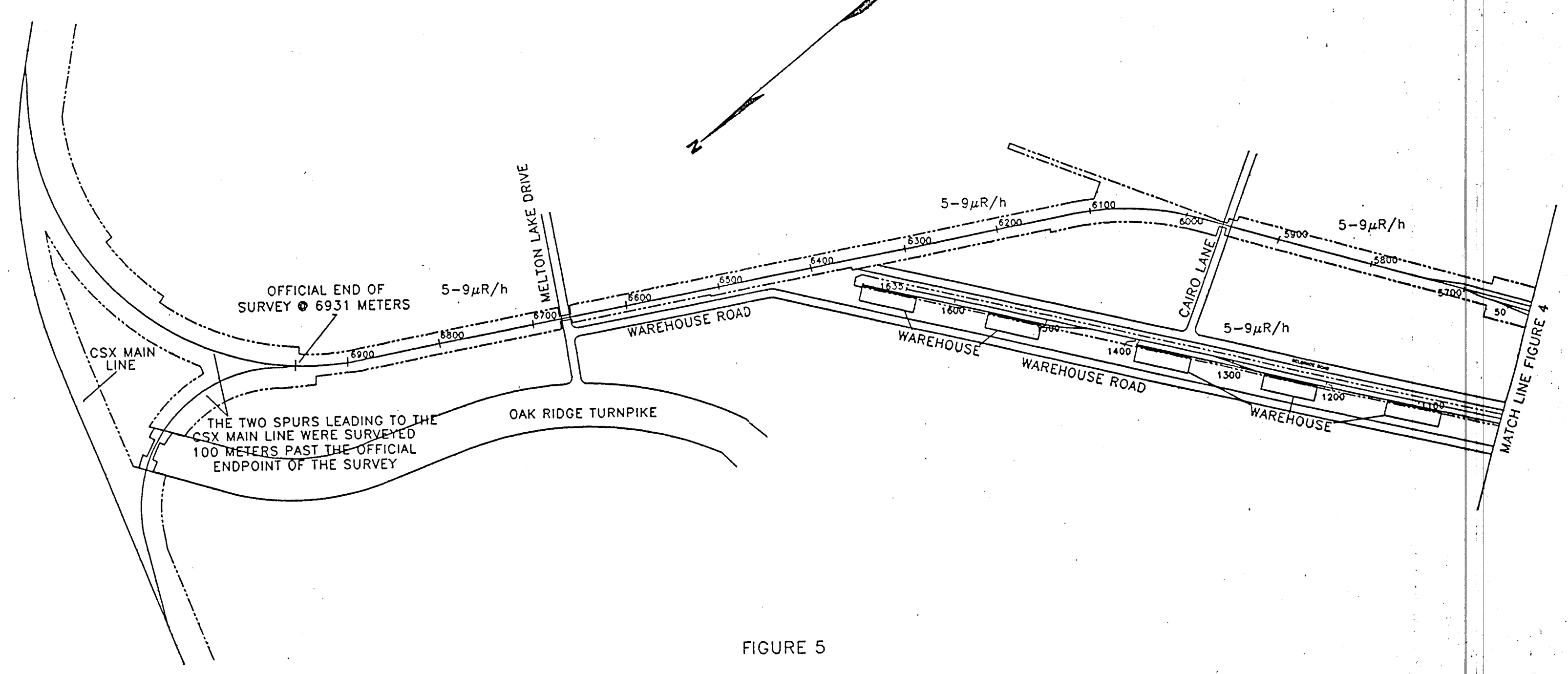

FIGURE 5

DETAIL

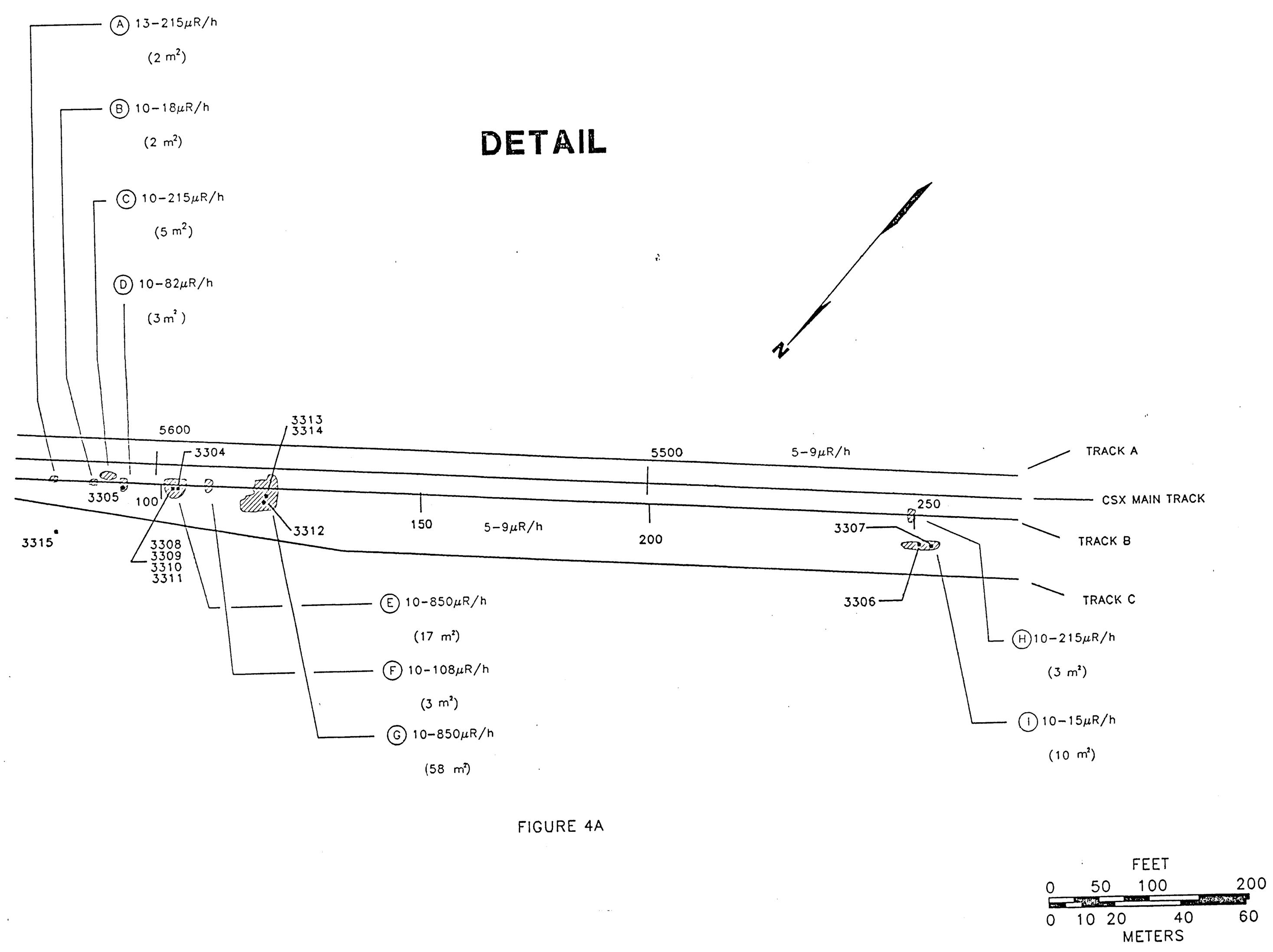

FIGURE 4A

ORNL

1990 CSX RAILROAD SURVEY

OAK RIDGE, TENNESSEE

FEET
0 200 400 800
0 40 80 160 240
METERS

Ⓐ REGION IDENTIFIER
• SOIL SAMPLE LOCATION
5-9μR/h GAMMA EXPOSURE RATE RANGE
CONTAMINATED REGION
RAILROAD TRACK
RAILROAD PROPERTY BOUNDARY
3301 SOIL SAMPLE NUMBER

#161

REV 09/06/90